Indian Satellite Data for Air Quality Monitoring

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NASA – ARSET at IITM, Pune, 23 – 26 May 2017

Air Quality Monitoring and Prediction

What we need for making useful Prediction ?

1. Assess Current Air Quality Condition

- Before we look into tomorrow, we need to understand what is happening now
- Current State

2. Digest Observational Information

- Bring observed data into standard format ← (Indian satellite data)
- Data assimilation

3. Project Current State into tomorrow

- Based on laws of physics
- Model simulation

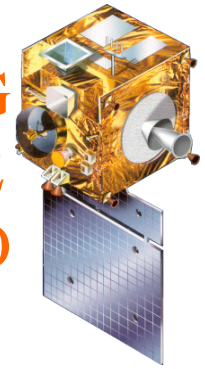
4. Apply Model Prediction Information

- Statistical Post-processing
- User applications

Indian Missions for Weather & Climate Studies : Current & Future

GEO

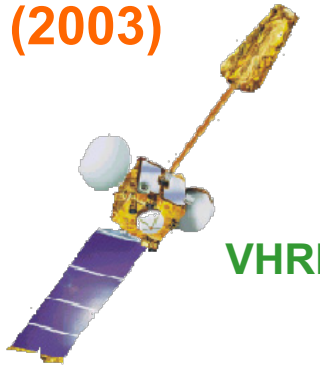
Kalpana-1
2002



VHRR

CMV, OLR, UTH,Rain

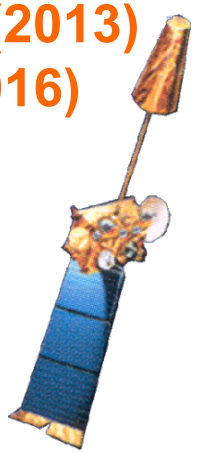
INSAT-3A
(2003)



VHRR, CCD

CMV, OLR, UTH, Rain
Aerosol

INSAT-3D (2013)
3DR (2016)



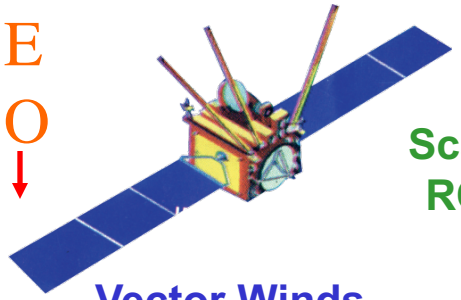
6-Ch VHRR
IR Sounder

SST, CMV, OLR, UTH, Rain,
T, h Profile, Ozone

- **GISAT (2018)**

LEO

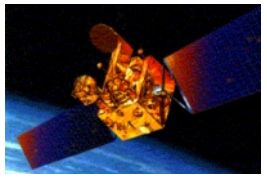
OCEANSAT–1/2
(1999/2009-09-23)
SCATSAT(2016)



MSMR,
OCM,
Scatterometer
ROSA (GPS)

Vector Winds,
Aerosol, T&h Profile

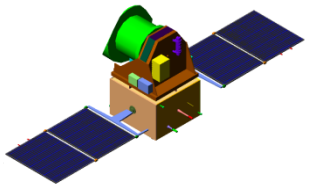
SARAL
(2013)



Altimeter

SSH, Waves, Winds

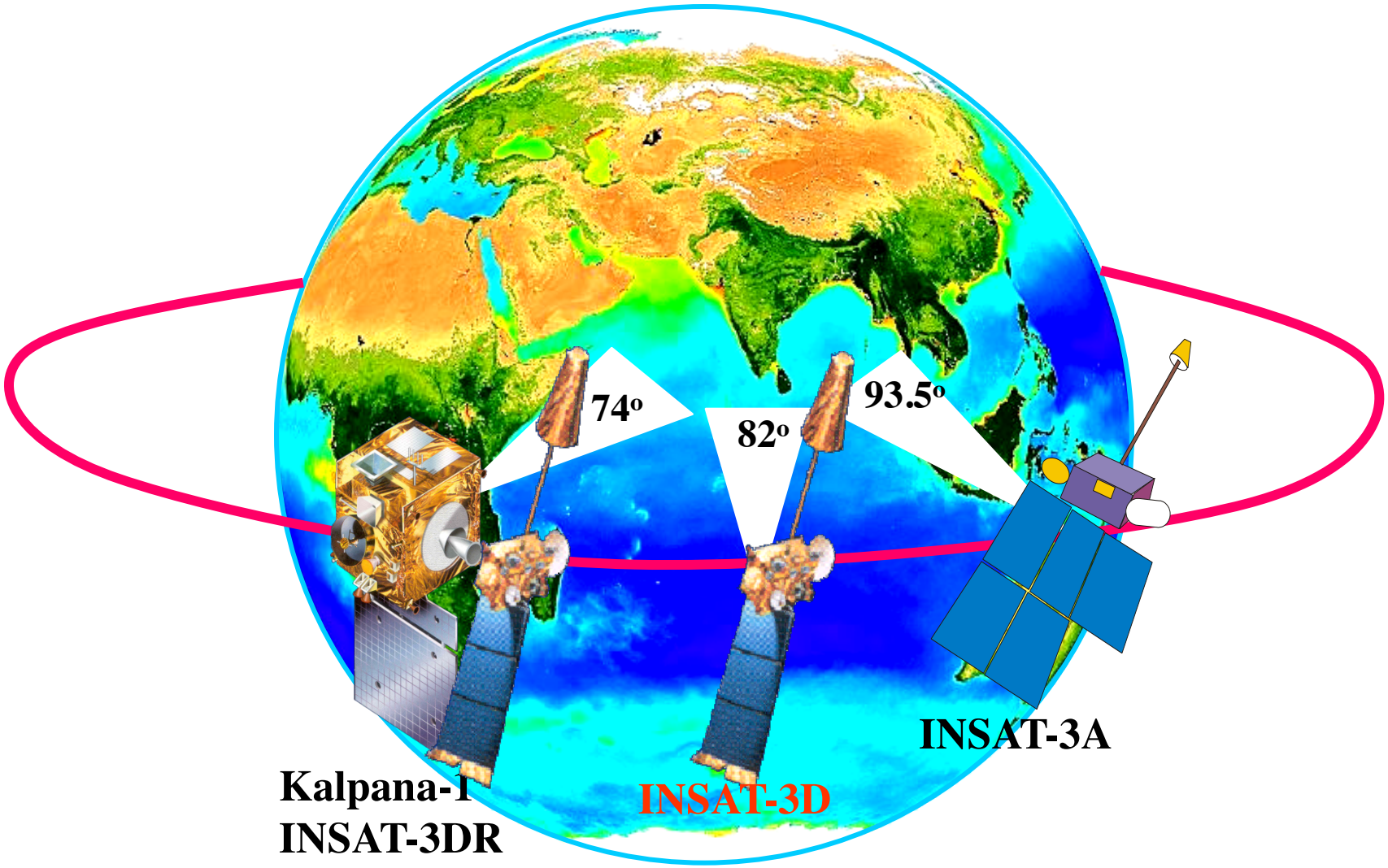
MEGHA-TROPIQUES
(2011)



MW Imager,
WV Sounder,
ScaRaB
ROSA

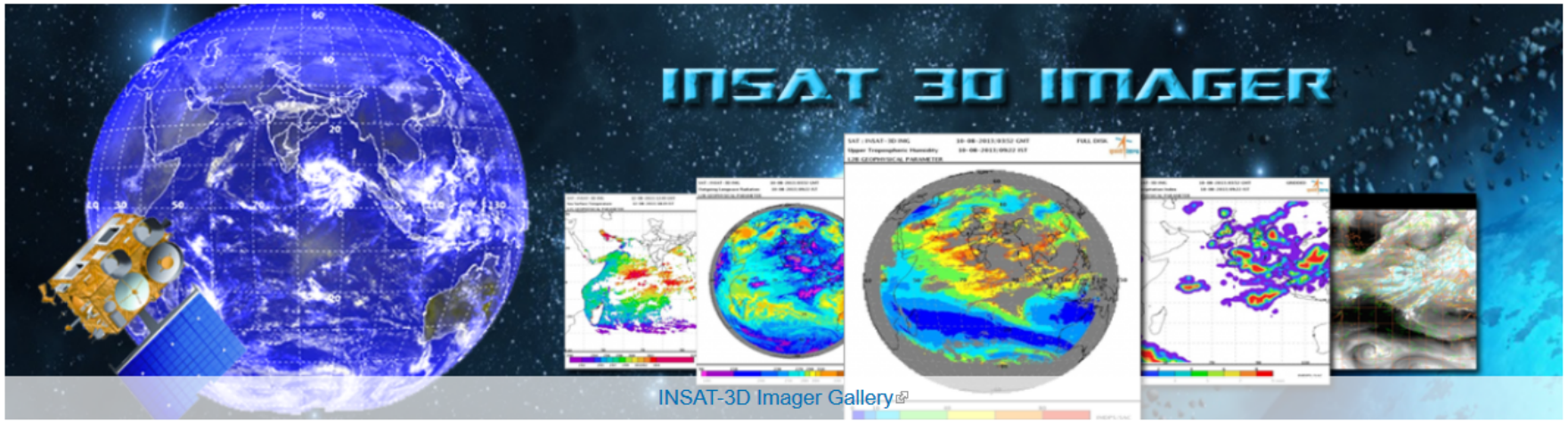
SS Wind, TWV, Rainfall
T, h Profile,
Radiation Budget

Current Indian Geostationary Meteorological Satellites



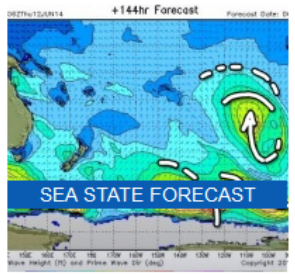
Monsoon Prediction 2017 | Monsoon Onset 2017

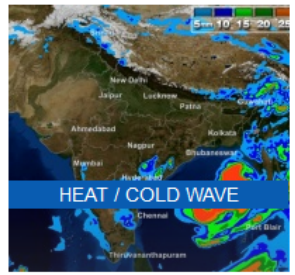
Highlights | Satellite Images | RADAR



Services

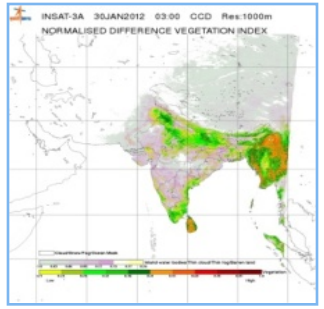
Forecast | Nowcast | Current Events | Past Events | Advisories | Visualisation | Met Applications | Ocean Applications



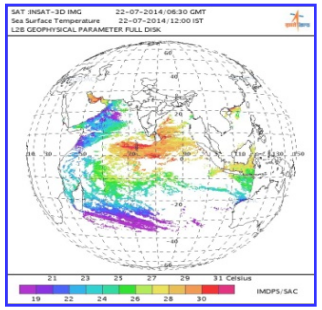


MOSDAC

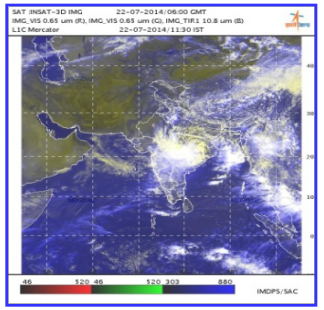
Sample Satellite Data Products



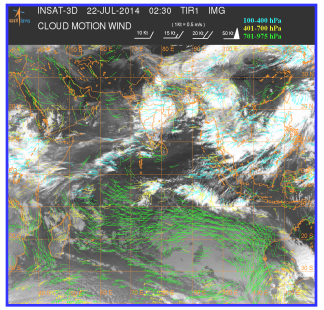
NDVI



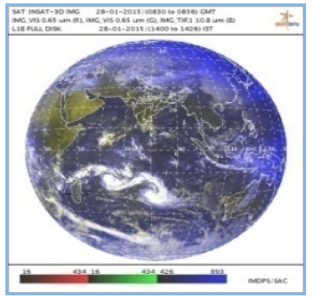
SST



Sector Product



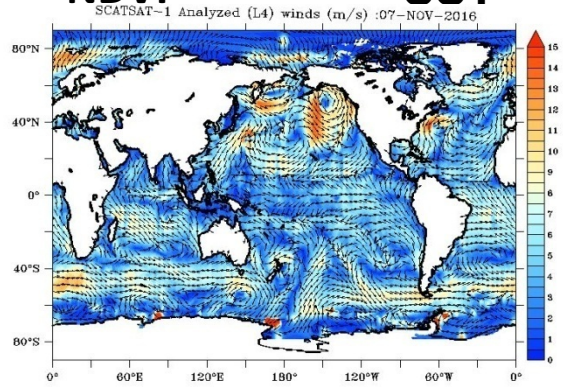
WINDS

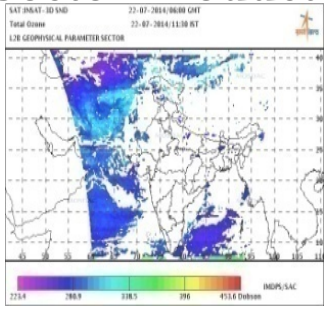


Full Disk Visible

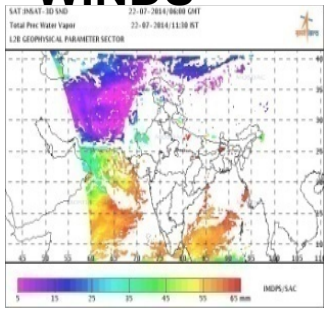
INSAT – 3A / KALPANA / 3D / 3DR

SCATSAT - 1

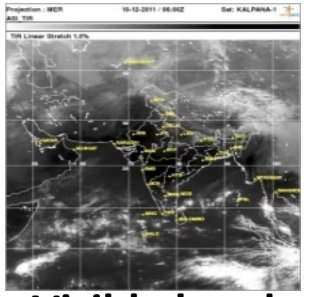




Total Ozone

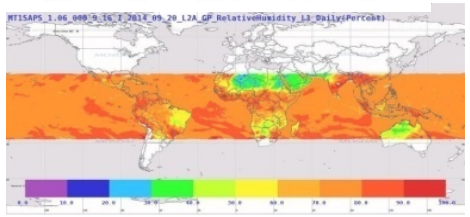


TPW

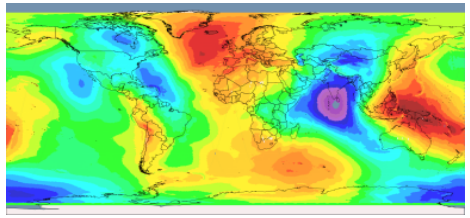


Visible band Asian sector

MEGHA TROPIQUES

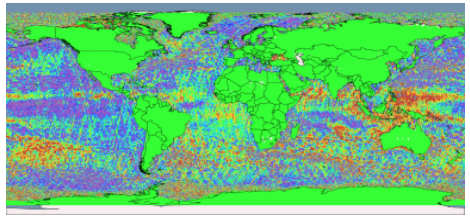


Relative humidity

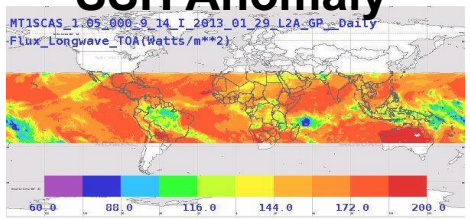


Mean sea surface

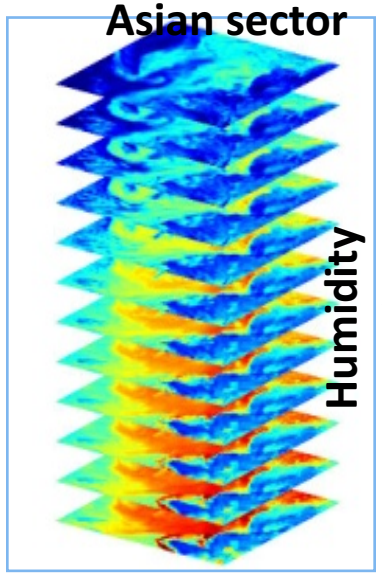
SARAL ALTIKA



SSH Anomaly



Daily long wave flux from SCARAB



Humidity Profile

INSAT 3D SOUNDER

www.mosdac.gov.in

INSAT - 3D / 3DR

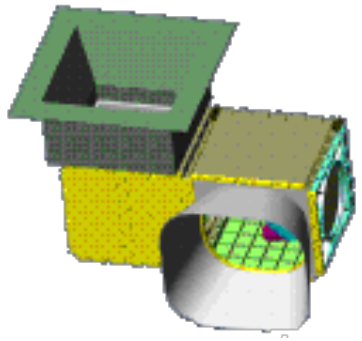
Improved Understanding of Mesoscale Systems

6 Channel IMAGER

- Spectral Bands (μm)

Visible	: 0.55 - 0.75
Short Wave Infra Red	: 1.55 - 1.70
Mid Wave Infra Red	: 3.80 – 4.00
Water Vapour	: 6.50 - 7.10
Thermal Infra Red – 1	: 10.30 - 11.30
Thermal Infra Red – 2	: 11.50 - 12.50

- Resolution : 1 km for VIS, SWIR
  4 km for MIR, TIR
  8 km for WV



19 Channel SOUNDER

- Spectral Bands (μm)

Short Wave Infra Red	: Six bands
Mid Wave Infra Red	: Five Bands
Long Wave Infra Red	: Seven Bands
Visible	: One Band

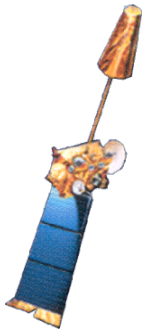
- Resolution (km) : 10 X 10 km all bands
- No of simultaneous sounding per band : Four

NINETEEN CHANNEL ATMOSPHERIC SOUNDER

with a resolution of 10 km at Sub-Satellite

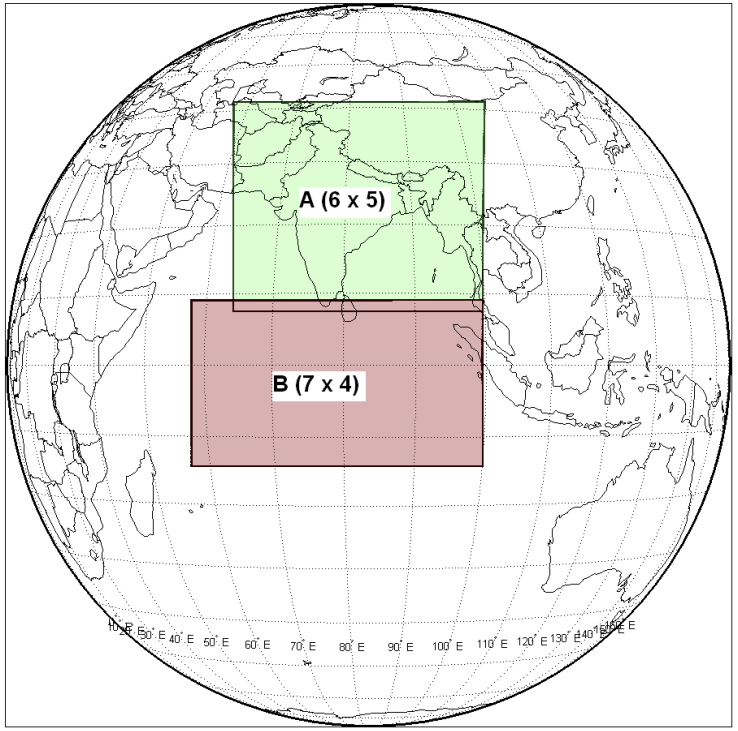
Channel No.	Central Wavelength (in μm)	Principal absorbing constituents
1	14.71	CO_2 – band
2	14.37	CO_2 – band
3	14.06	CO_2 – band
4	13.64	CO_2 – band
5	13.37	CO_2 – band
6	12.66	water vapor
7	12.02	water vapor
8	11.03	window
9	9.71	ozone
10	7.43	water vapor
11	7.02	water vapor
12	6.51	water vapor
13	4.57	N_2O
14	4.52	N_2O
15	4.45	CO_2
16	4.13	CO_2
17	3.98	window
18	3.74	window
19	0.69	vis

Only Sounder in Geostationary orbit, after GOES



Temperature and humidity profile
Total Ozone and Ozone profile
Derived products

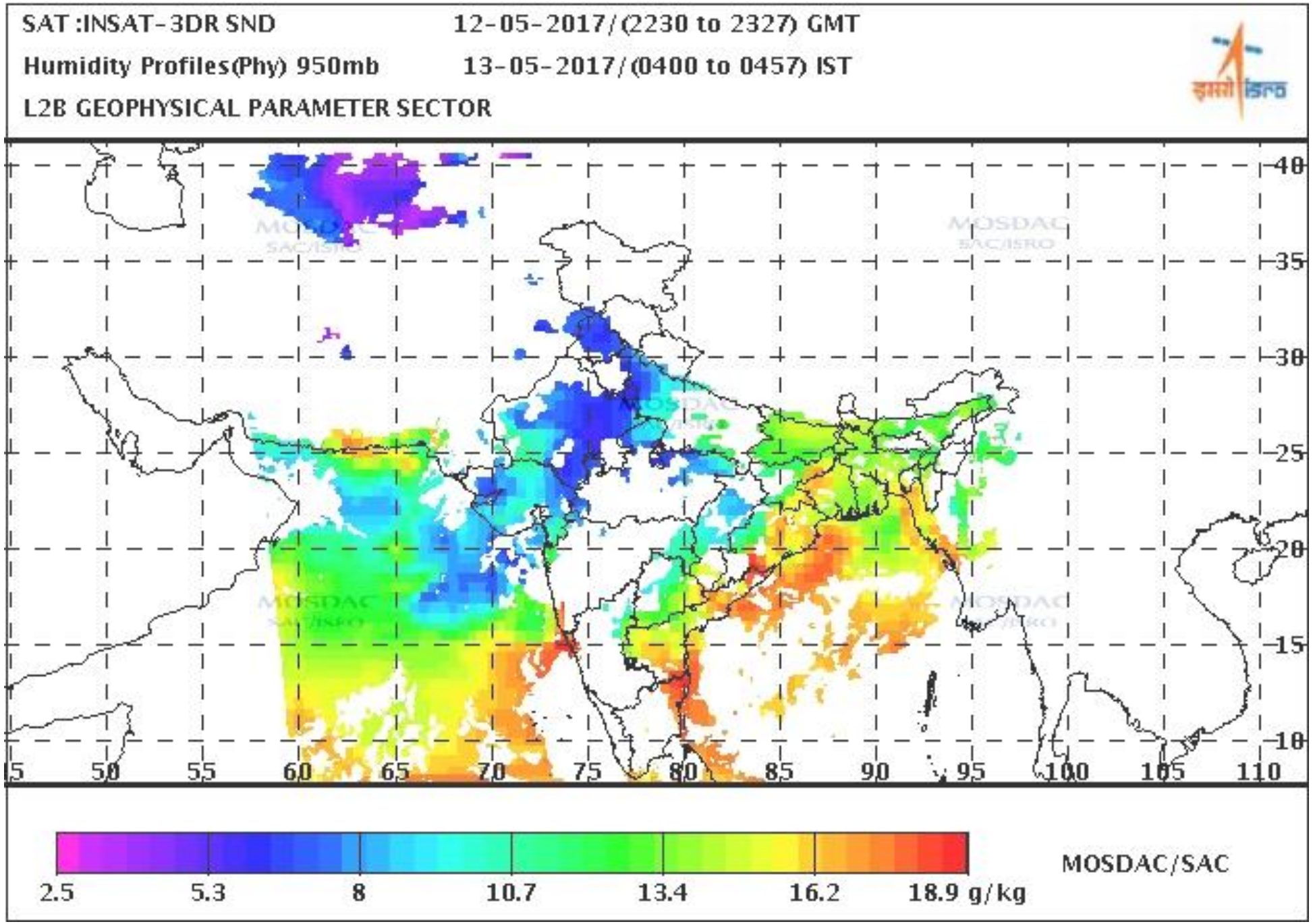
Sounder Observation Area

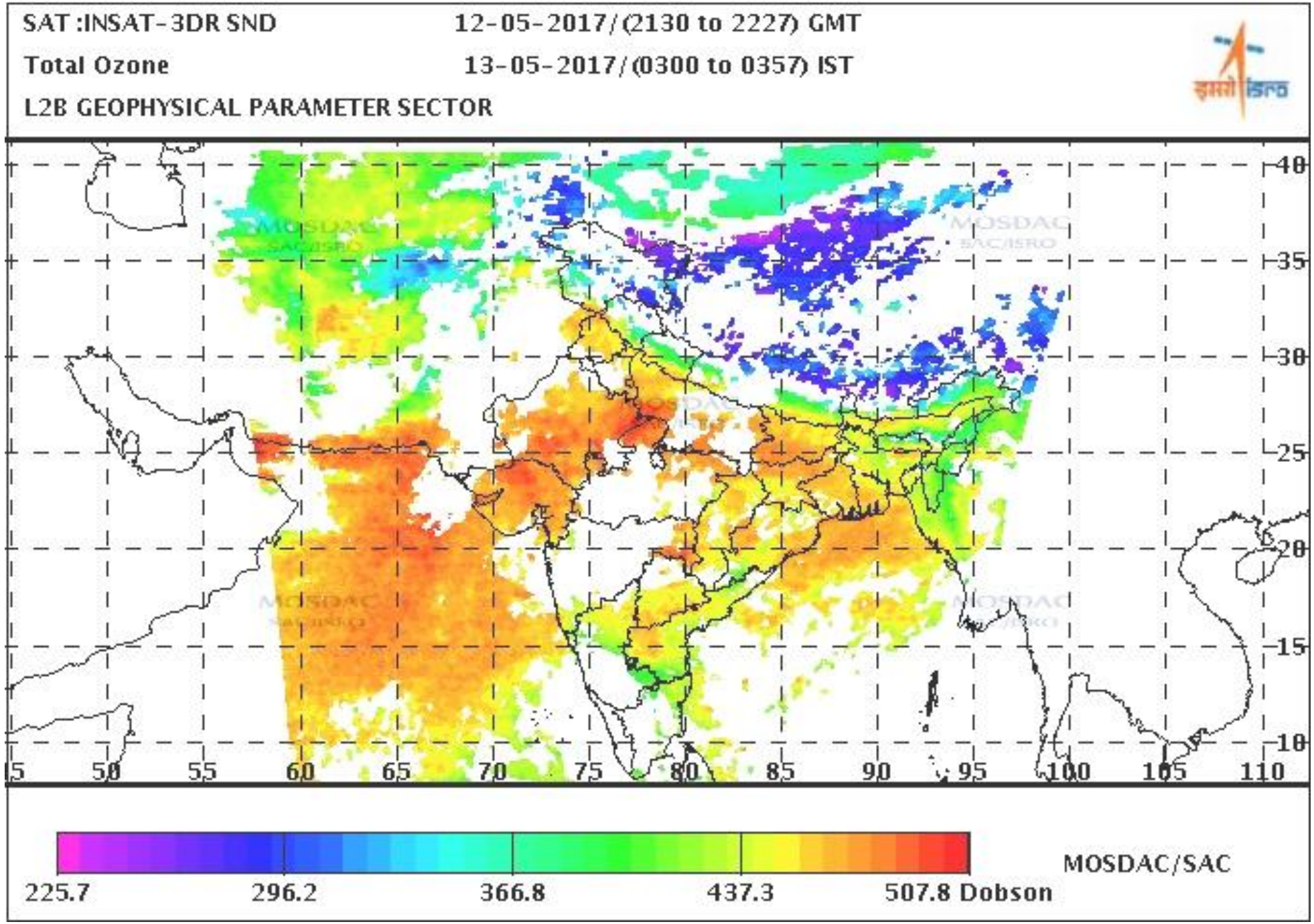


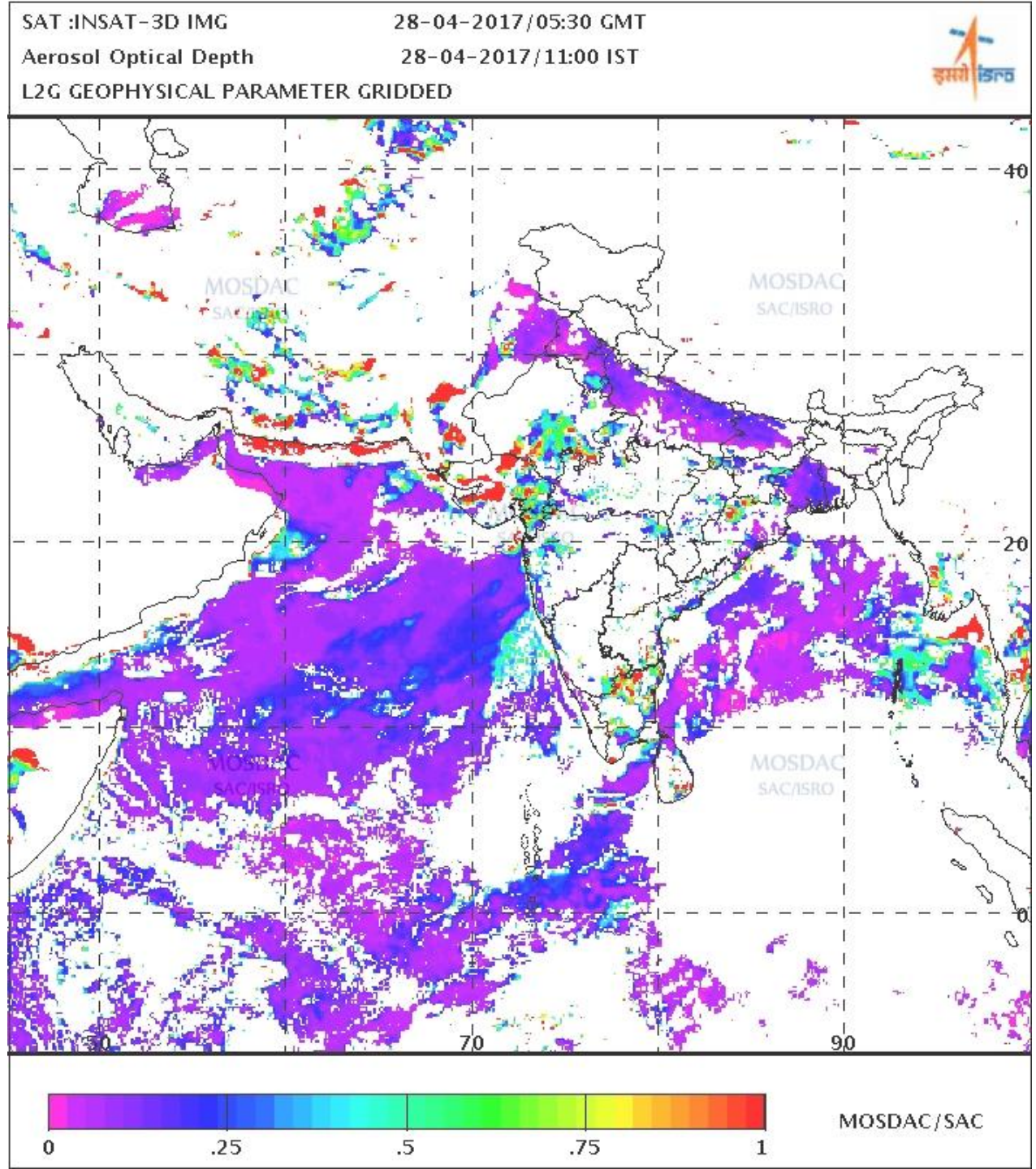
Geophysical Parameters from INSAT-3D

No.	Parameters	Input Channels
1	*Outgoing Longwave Radiation (OLR)*	TIR-1, TIR -2, WV
2	*Quantitative Precipitation Estimation (QPE)*	TIR-1, TIR- 2
3	*Sea Surface Temperature (SST) & Land surface Temperature (LST)*	SWIR,TIR – 1, TIR - 2, MIR
4	*Snow cover*	VIS, SWIR, TIR – 1, TIR –2
6	*Fire/Smoke/Aerosol*	VIS,MIR, TIR -1, TIR-2,MIR
7	*Atmospheric Motion Vector (AMV)*	TIR-1, TIR –2, VIS, WV
8	*Upper Tropospheric Humidity (UTH)*	TIR-1,TIR –2, WV
9	*Temperature, Humidity profile*	Sounder Channels
10	*Total Ozone*	Sounder Channels
11	*Value added parameters from sounder products*	Sounder products

Some important parameters from INSAT-3D / 3DR for Air Quality Modeling


SAT :INSAT-3DR SND
12-05-2017/(2230 to 2327) GMT
Humidity Profiles(Phy) 950mb
13-05-2017/(0400 to 0457) IST
L2B GEOPHYSICAL PARAMETER SECTOR
40
35
30
25
20
15
10
45
50
55
60
65
70
75
80
85
90
95
100
105
110
2.5
5.3
8
10.7
13.4
16.2
18.9 g/kg
MOSDAC/SAC

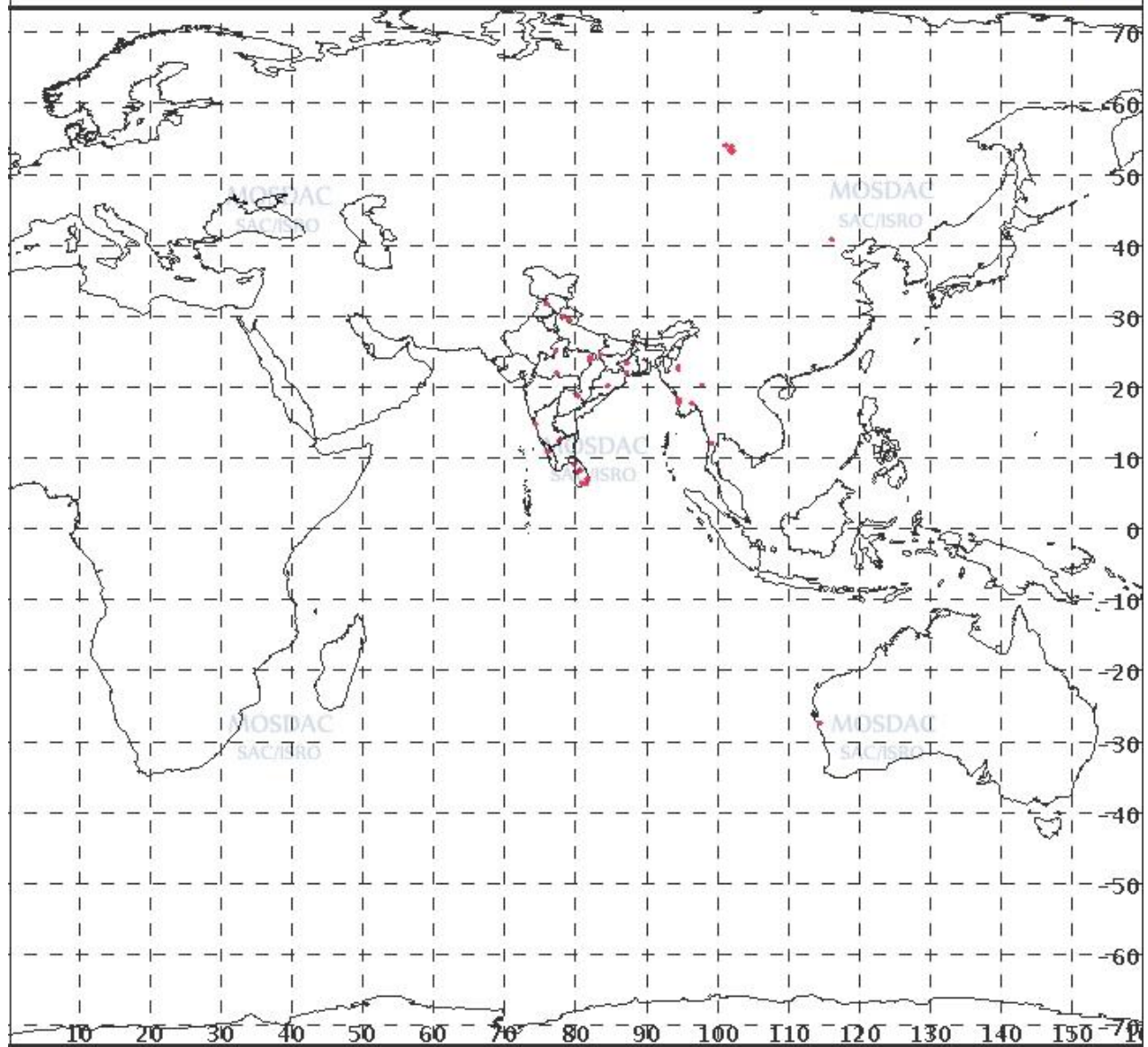

SAT :INSAT-3DR SND
12-05-2017/(2130 to 2227) GMT
Total Ozone
13-05-2017/(0300 to 0357) IST
L2B GEOPHYSICAL PARAMETER SECTOR
40
35
30
25
20
15
10
45
50
55
60
65
70
75
80
85
90
95
100
105
110
225.7
296.2
366.8
437.3
507.8 Dobson
MOSDAC/SAC


SAT :INSAT-3D IMG
28-04-2017/05:30 GMT
Aerosol Optical Depth
28-04-2017/11:00 IST
L2G GEOPHYSICAL PARAMETER GRIDDED
40
20
0
70
90
MOSDAC
SAC/ISRO
0
.25
.5
.75
1
MOSDAC/SAC

SAT :INSAT-3D IMG 28-04-2017/05:00 GMT

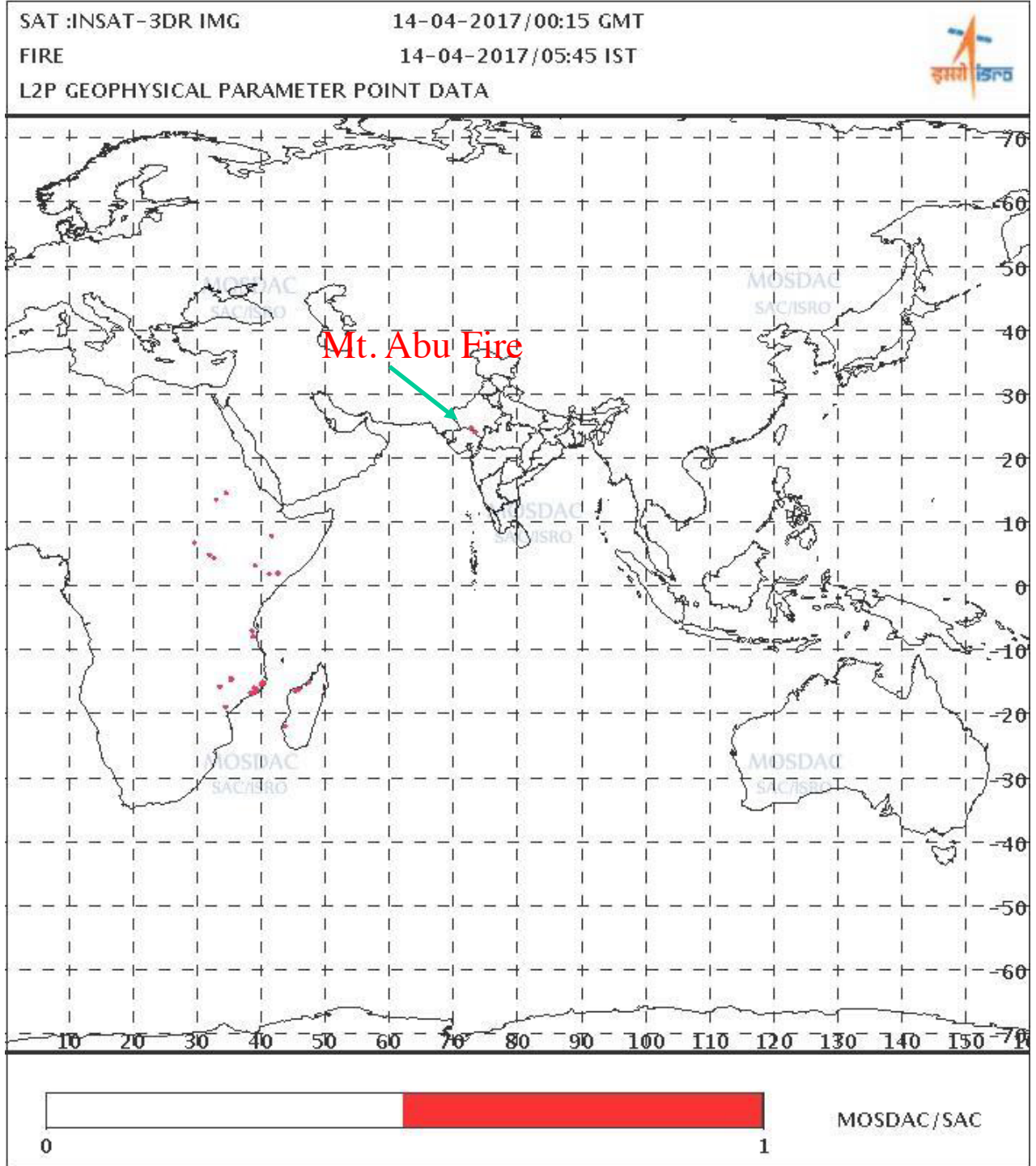
FIRE 28-04-2017/10:30 IST

L2P GEOPHYSICAL PARAMETER POINT DATA



0 1

MOSDAC/SAC

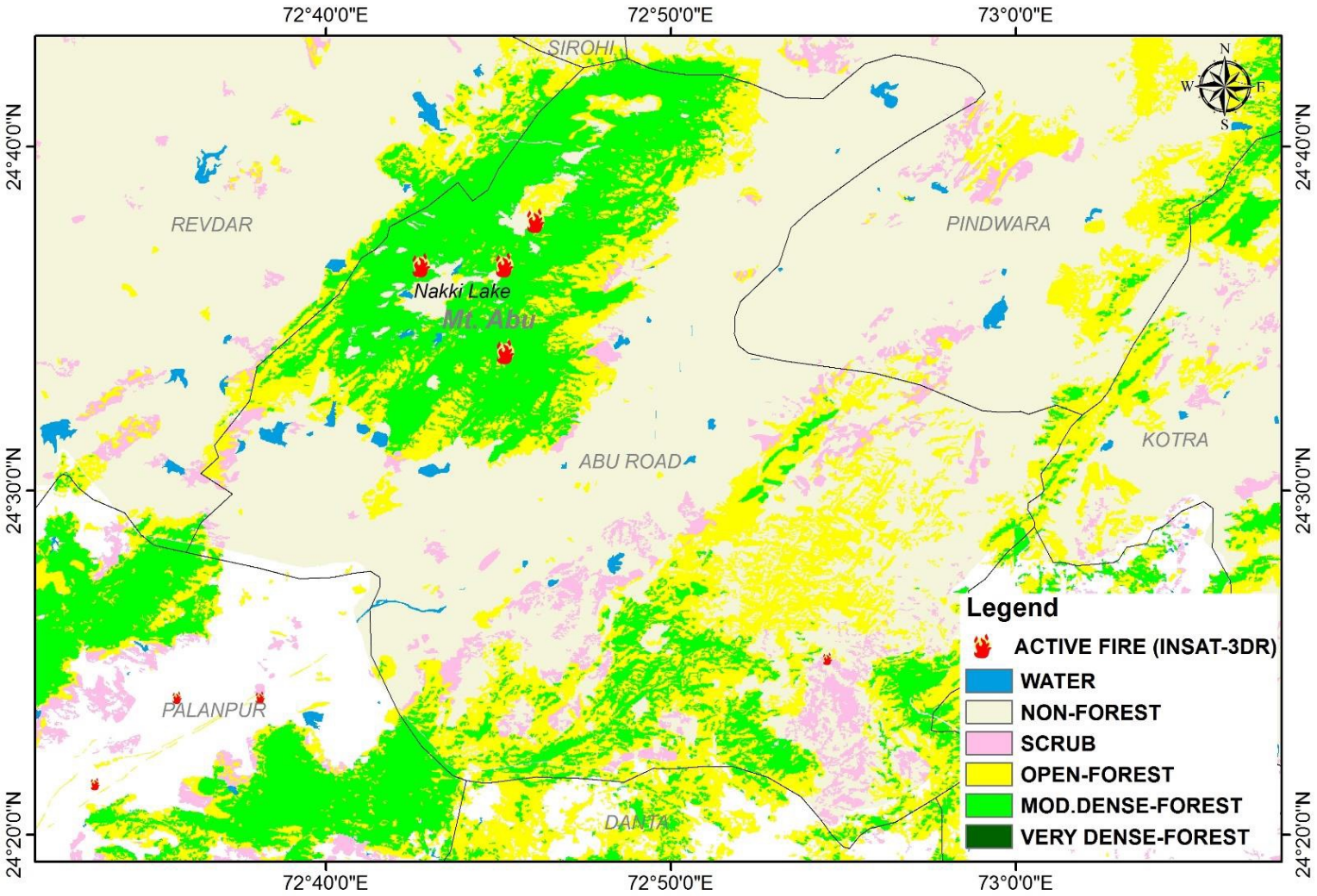


Active Forest Fire detected in Mt Abu By INSAT 3DR Imager (14th April to 15th April 2017)

As IAF operation started to douse the fire, the fire diminished and there were no fire points in 15th image. However scattered fire of small sizes were reported which were undetected due to coarse resolution of 4x4 km.

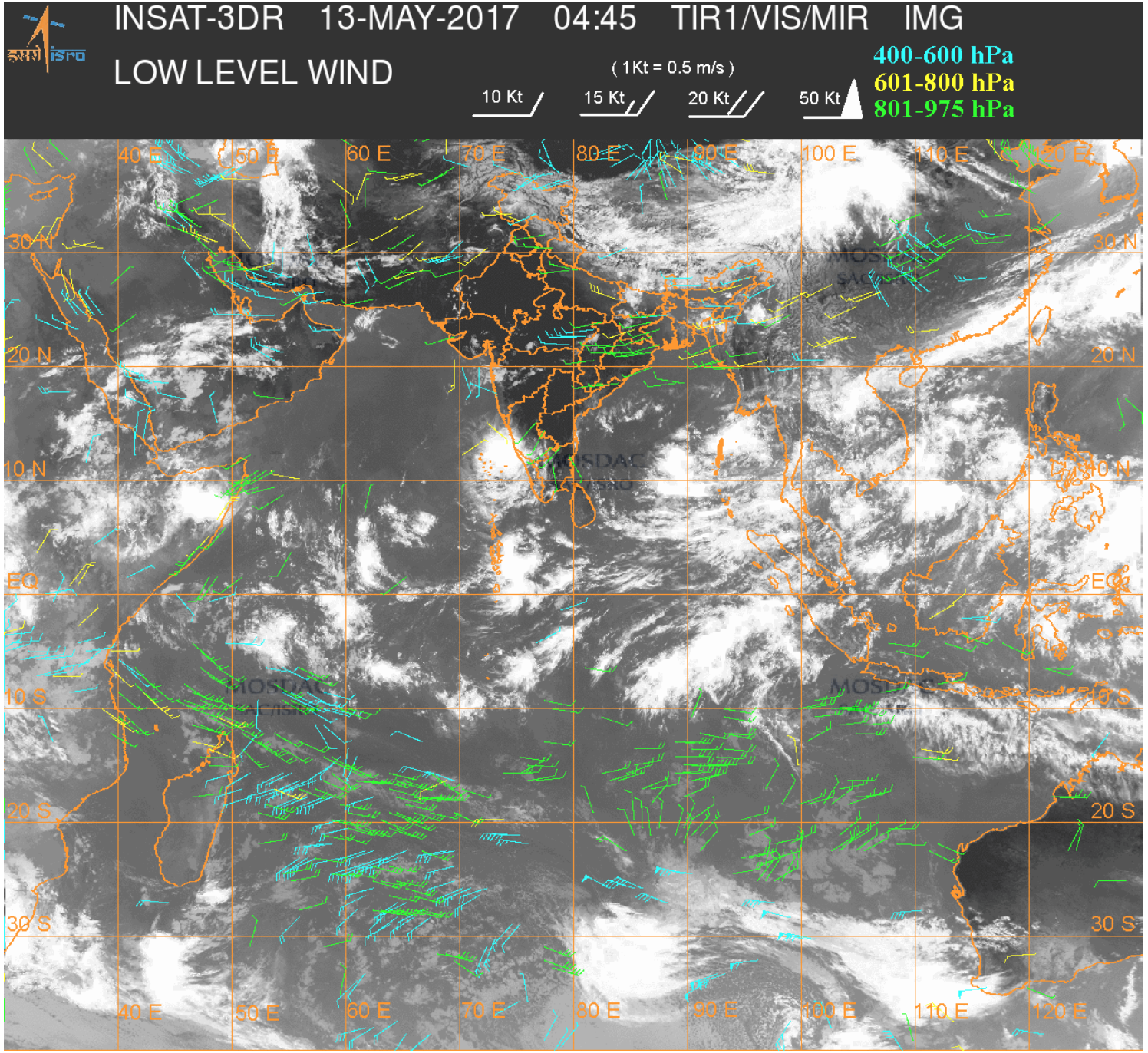
Forest Fire in Mt. Abu detected by INSAT-3DR Imager

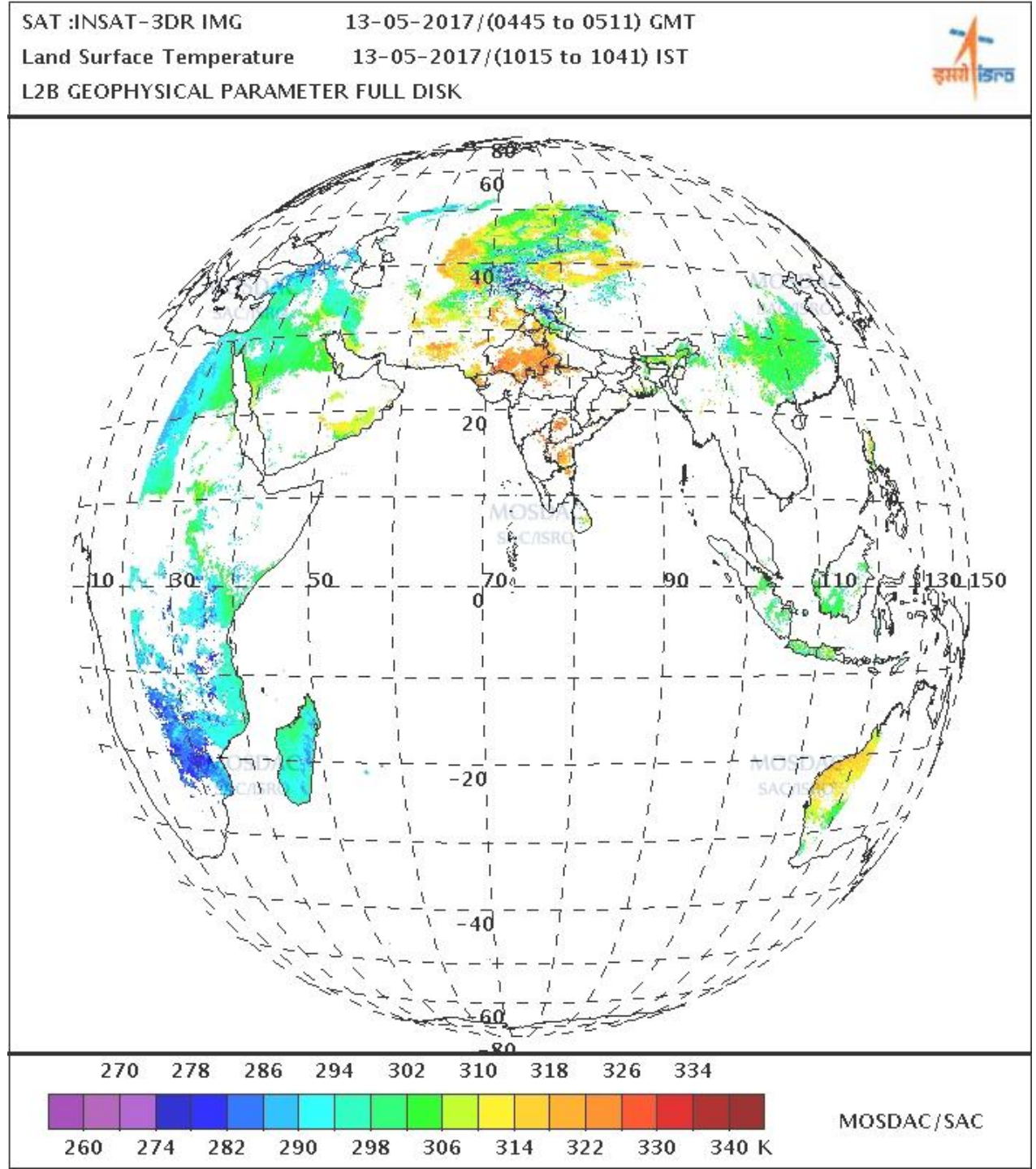
A forest fire broke in the hills of Mount Abu on Friday morning (14th April, 2017) which is captured by fire product from INSAT-3DR

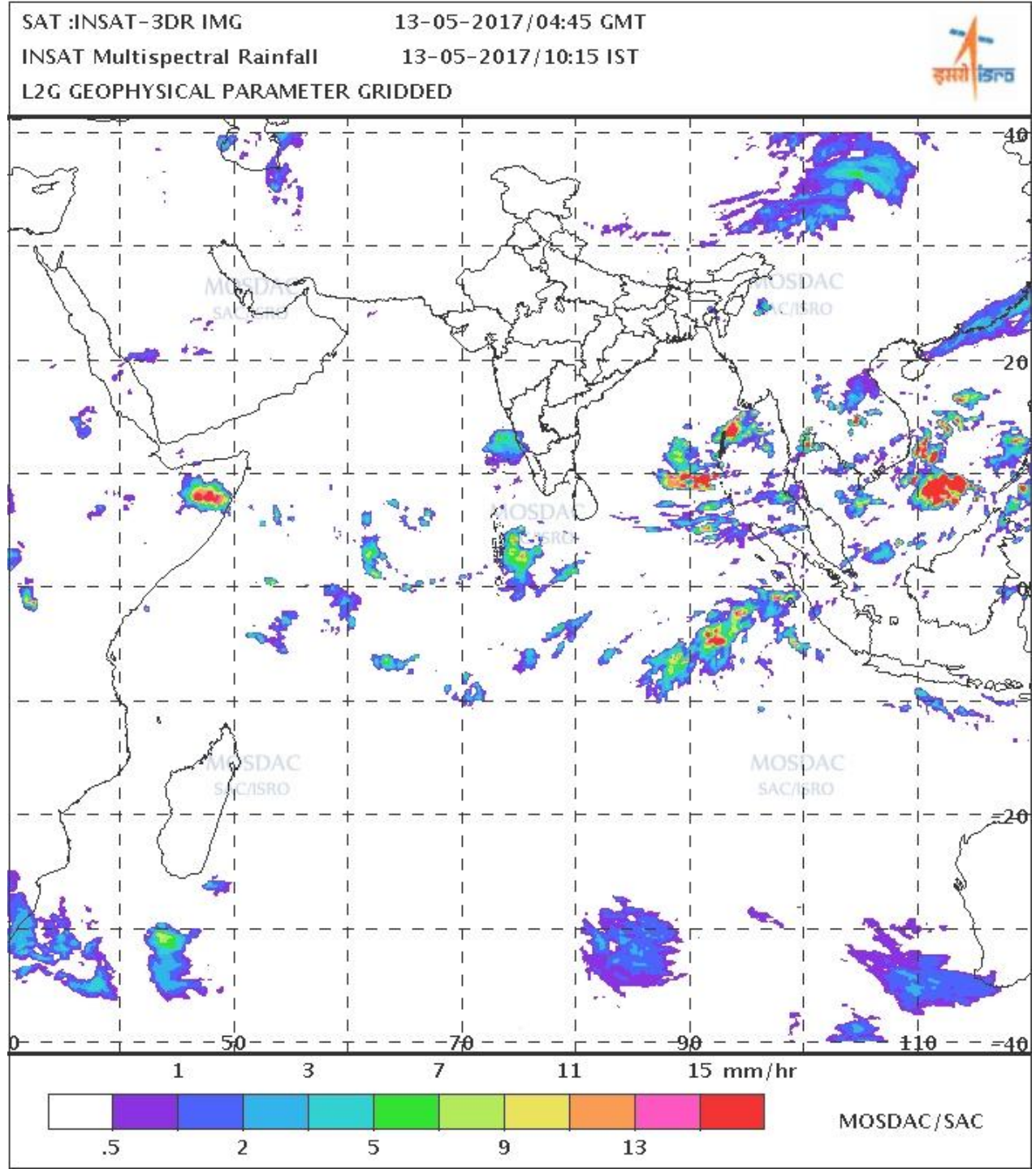


Fire Detection Time (3DR)

13-APR-2017 23:03:55 UTC
14-APR-2017 00:33:56 UTC
14-APR-2017 12:03:55 UTC
14-APR-2017 12:33:55 UTC
14-APR-2017 13:33:55 UTC
14-APR-2017 14:33:54 UTC
14-APR-2017 15:03:55 UTC
14-APR-2017 17:03:54 UTC
14-APR-2017 22:33:54 UTC


INSAT-3DR 13-MAY-2017 04:45 TIR1/VIS/MIR IMG
LOW LEVEL WIND
(1Kt = 0.5 m/s)
10 Kt
15 Kt
20 Kt
50 Kt
400-600 hPa
601-800 hPa
801-975 hPa
40 E
50 E
60 E
70 E
80 E
90 E
100 E
110 E
120 E
30 N
20 N
10 N
EQ
10 S
20 S
30 S

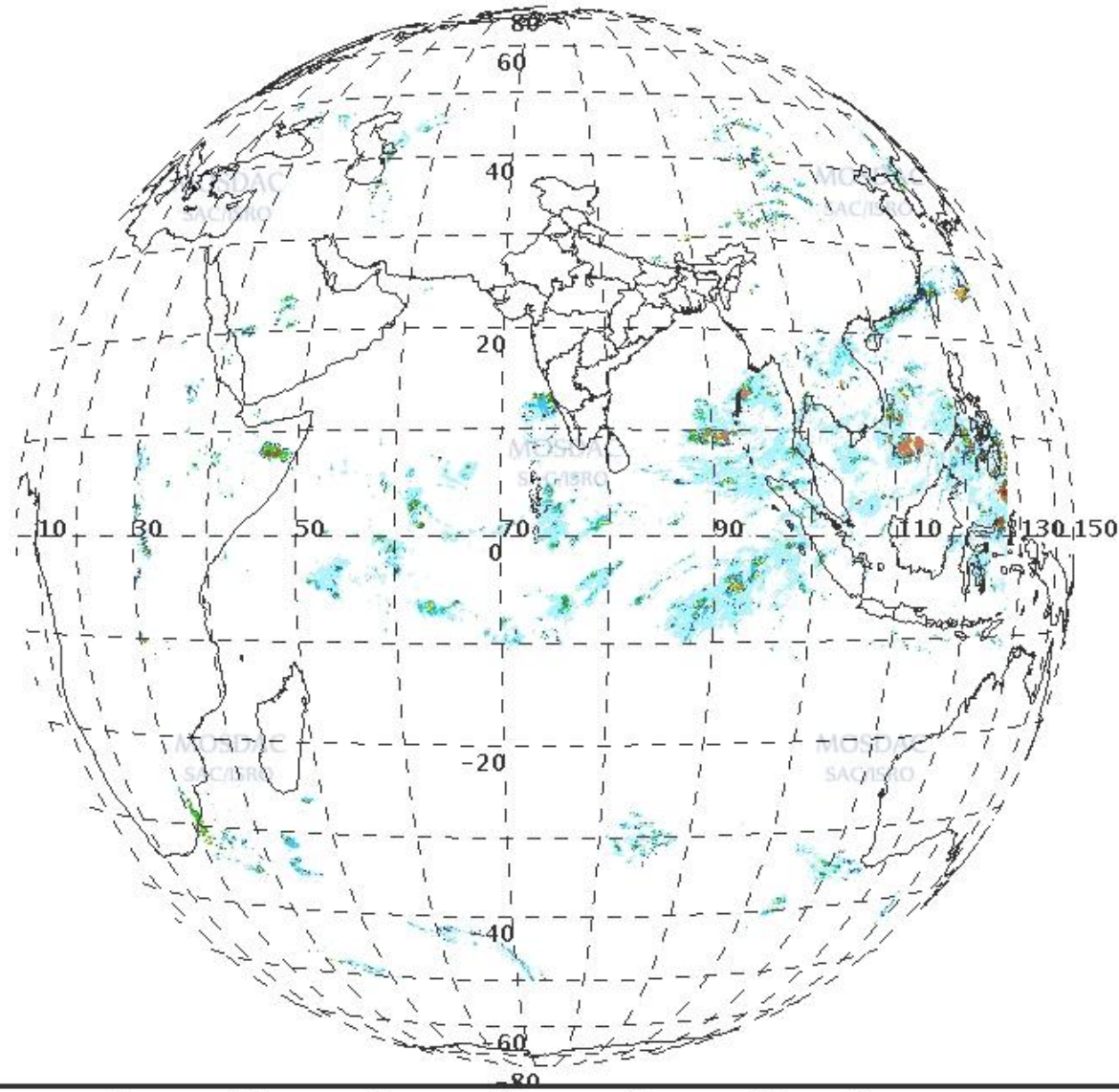

SAT :INSAT-3DR IMG 13-05-2017/(0445 to 0511) GMT
Land Surface Temperature 13-05-2017/(1015 to 1041) IST
L2B GEOPHYSICAL PARAMETER FULL DISK
80
60
40
20
0
-20
-40
-60
-80
10
30
50
70
90
110
130
150
270 278 286 294 302 310 318 326 334
260 274 282 290 298 306 314 322 330 340 K
MOSDAC/SAC


SAT :INSAT-3DR IMG 13-05-2017/04:45 GMT
INSAT Multispectral Rainfall 13-05-2017/10:15 IST
L2G GEOPHYSICAL PARAMETER GRIDDED
40
20
0
-20
-40
0
50
70
90
110
1
3
7
11
15 mm/hr
.5
2
5
9
13
MOSDAC/SAC

SAT :INSAT-3DR IMG 13-05-2017/(0445 to 0511) GMT

Hydro Estimator Precipitation 13-05-2017/(1015 to 1041) IST

L2B GEOPHYSICAL PARAMETER FULL DISK



.51 1.5 5 15 25 35 mm/hr

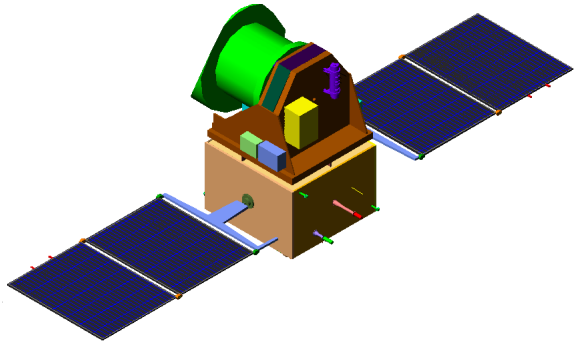
.02 1 2 10 20 30

MOSDAC/SAC

Megha Tropiques (2011)

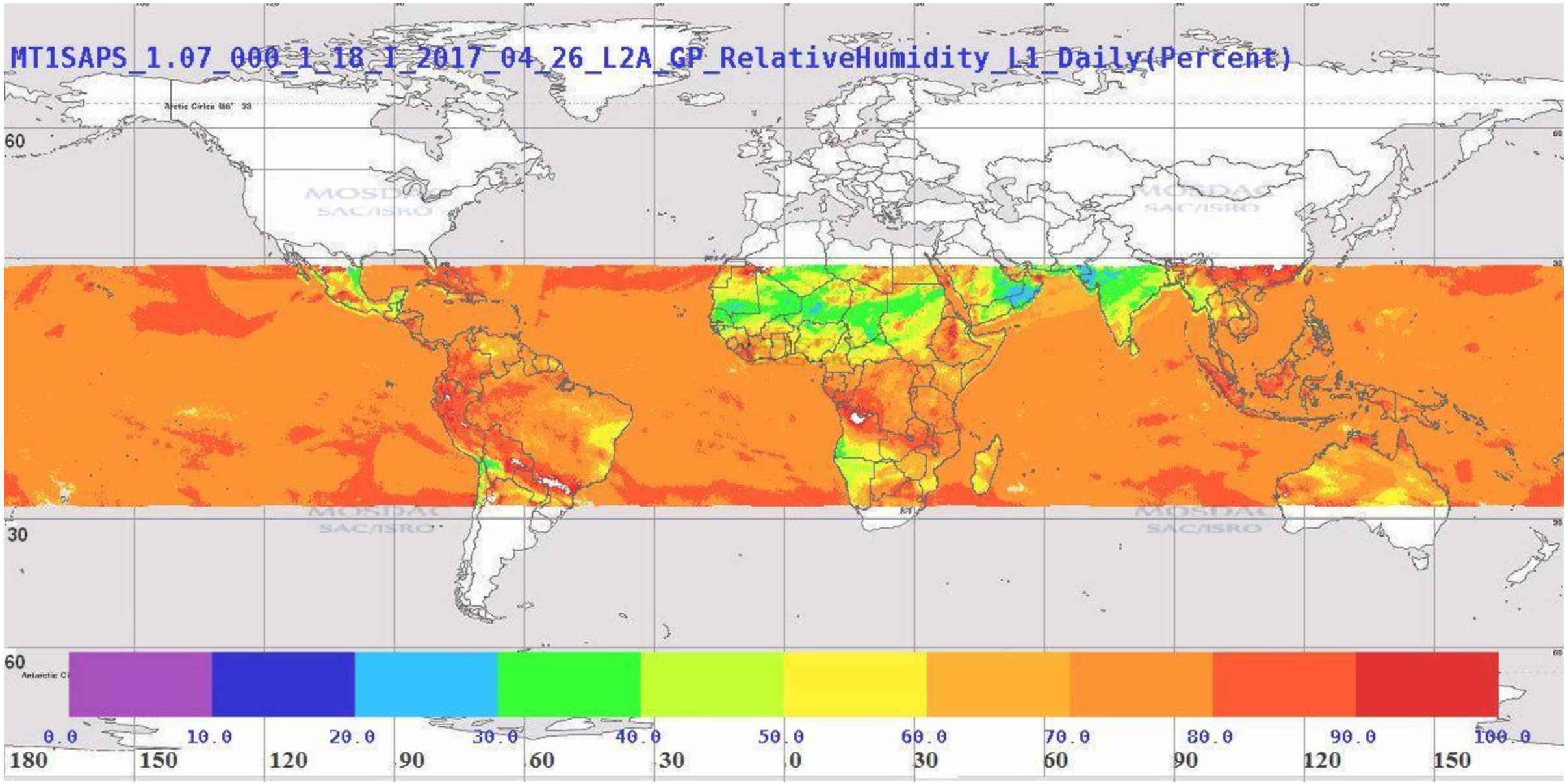
(ISRO-CNES)

Launch Vehicle	PSLV C-18
Bus	IRS
Year of Launch	~2010
Satellite Weight	500 kg
Satellite Altitude	~800 km
Inclination	~20°



Payloads

MADRAS	Pasive MW Radiometer 18-85 GHz, 157 GHz
SAPHIR	183 GHz WV Sounder
ScaRaB	Visible-IR Radiometer
ROSA	GPS-RO

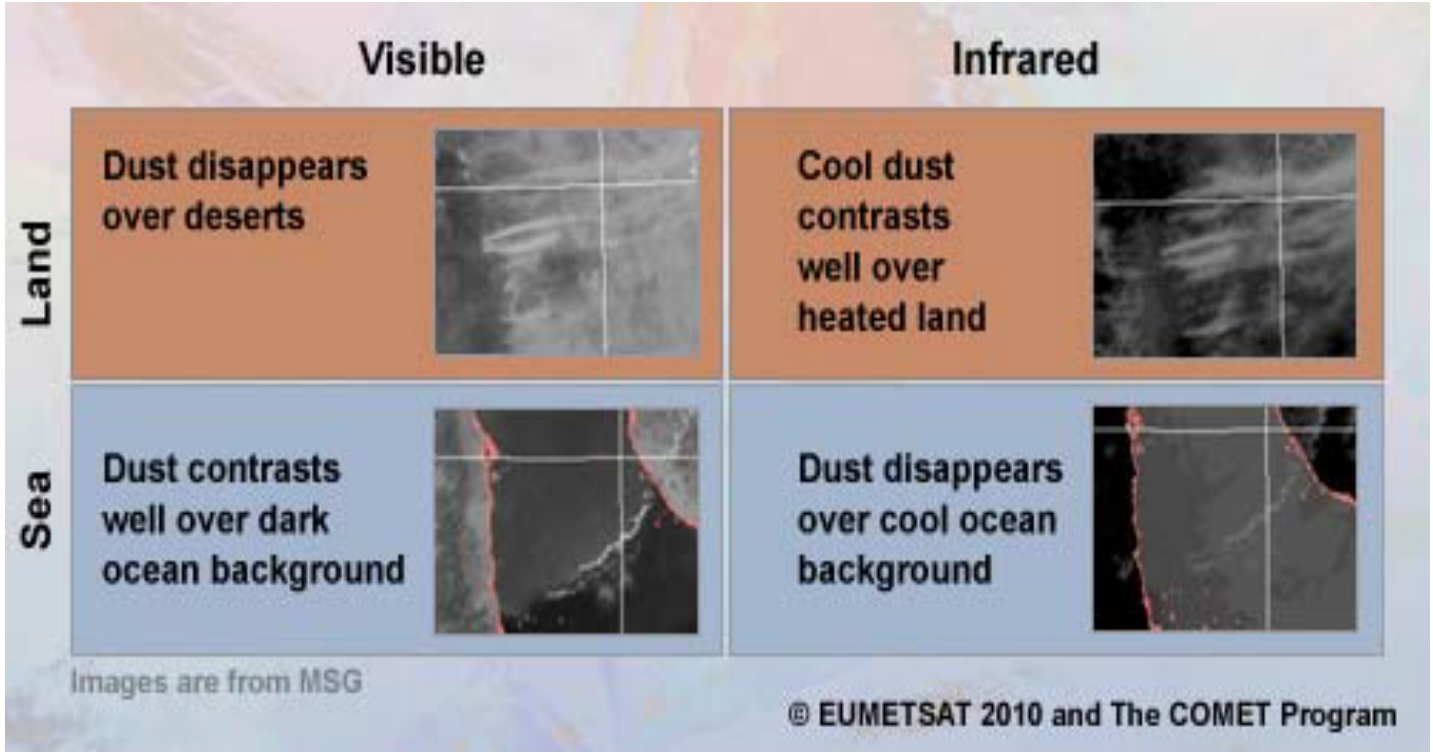

MT1SAPS_1.07_000_1_18_1_2017_04_26_L2A_GP_RelativeHumidity_L1_Daily(Percent)
60
30
60
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
180
150
120
90
60
30
0
30
60
90
120
150

Dust Storm Event

The dust blowing from Saudi Arabian Peninsula towards west coast of India is visible through INSAT-3D, Megha-Tropiques & KALPANA satellite images.

Satellite Observations of Dust

- Visible and infrared multispectral techniques
- In general, it's easier to detect dust during the day than at night
- Surface type also has a large impact on dust detection algorithm



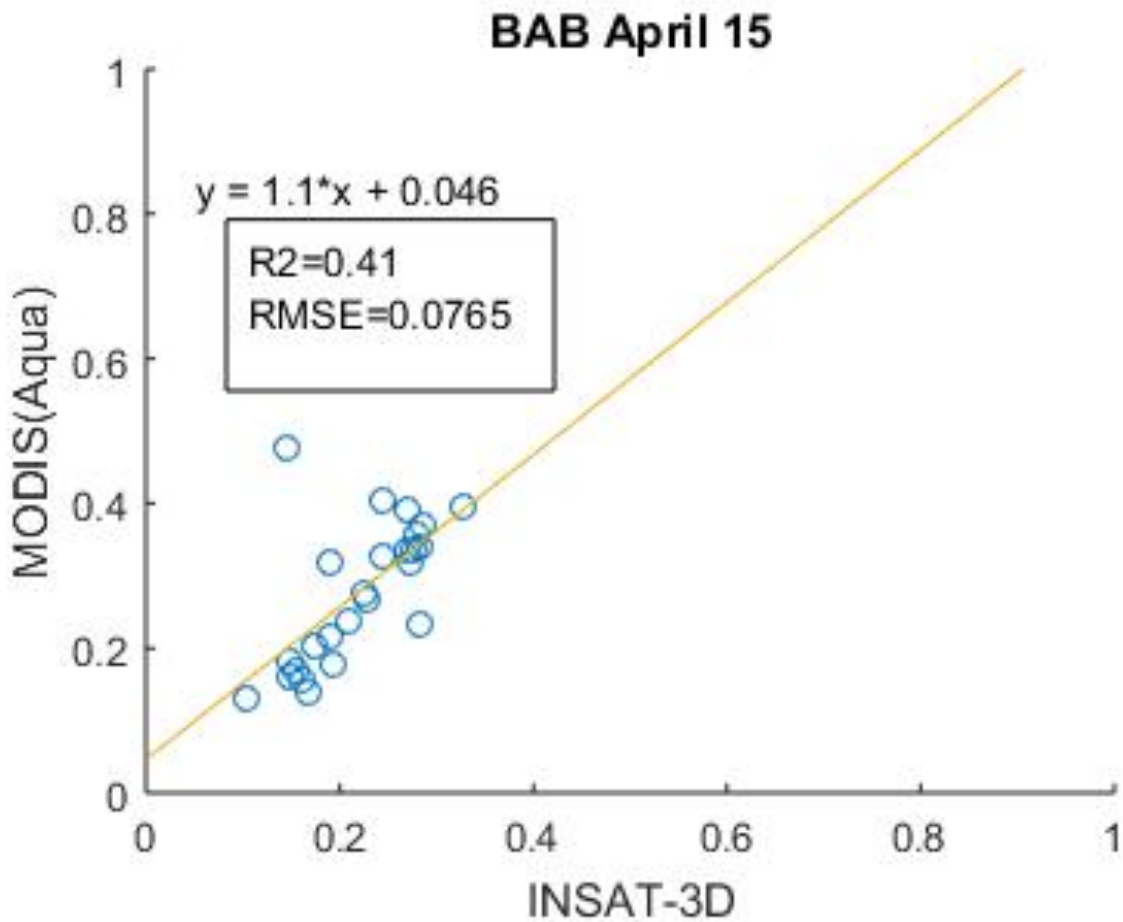
Satellite Observations of Dust

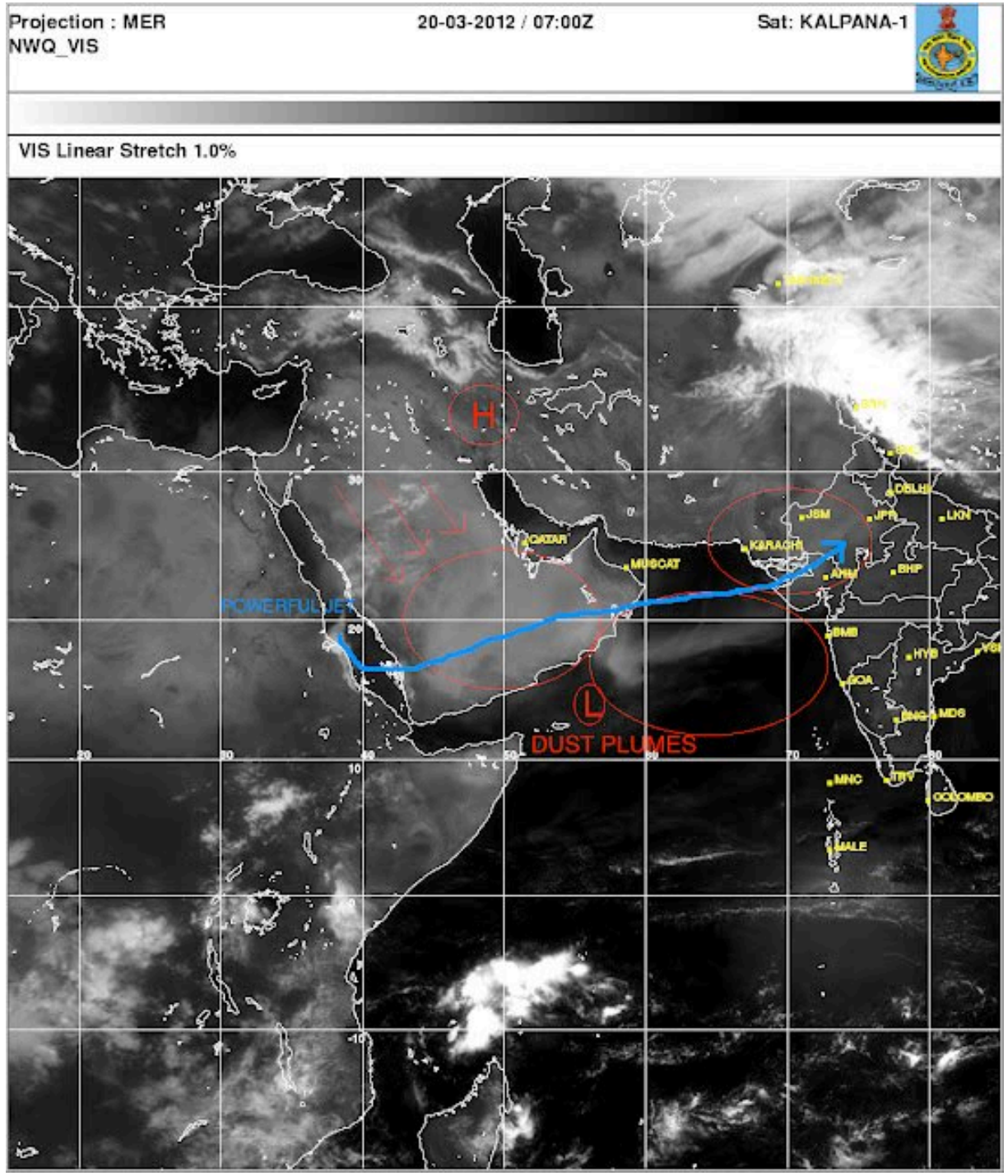
Aerosol Optical Depth (AOD)

AOD is a measure of the amount of light that airborne particles, such as dust, smoke, haze, and pollution, prevent from passing through a column of atmosphere.

AOD does not translate directly into surface visibility estimates because the location of the dust in the vertical is not known. it could be mostly aloft or near the surface.

AOD serves as a first-order indicator of how dusty the atmosphere is.

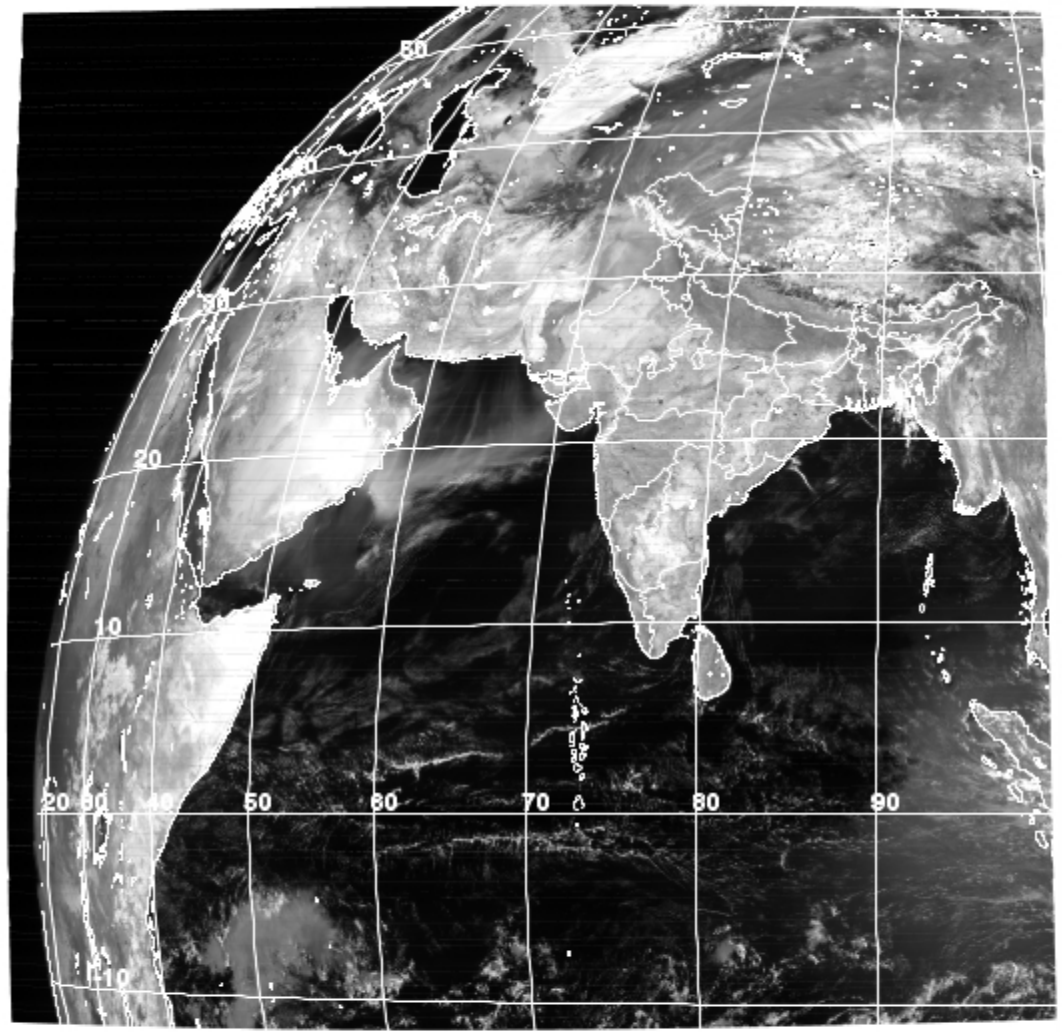

BAB April 15
y = 1.1*x + 0.046
R2=0.41
RMSE=0.0765
MODIS(Aqua)
INSAT-3D
0
0.2
0.4
0.6
0.8
1


Projection : MER
NWQ_VIS
20-03-2012 / 07:00Z
Sat: KALPANA-1
VIS Linear Stretch 1.0%
H
L
POWERFUL JET
DUST PLUMES
DOHA
MUSCAT
KARACHI
DELHI
JSM
JPR
LKO
AMD
BHP
BMB
HYD
GOA
BNG
MDS
MNC
TRV
COLOMBO
MALE

Projection : None 20-03-2012 / 05:00Z Sat: INSAT-3A

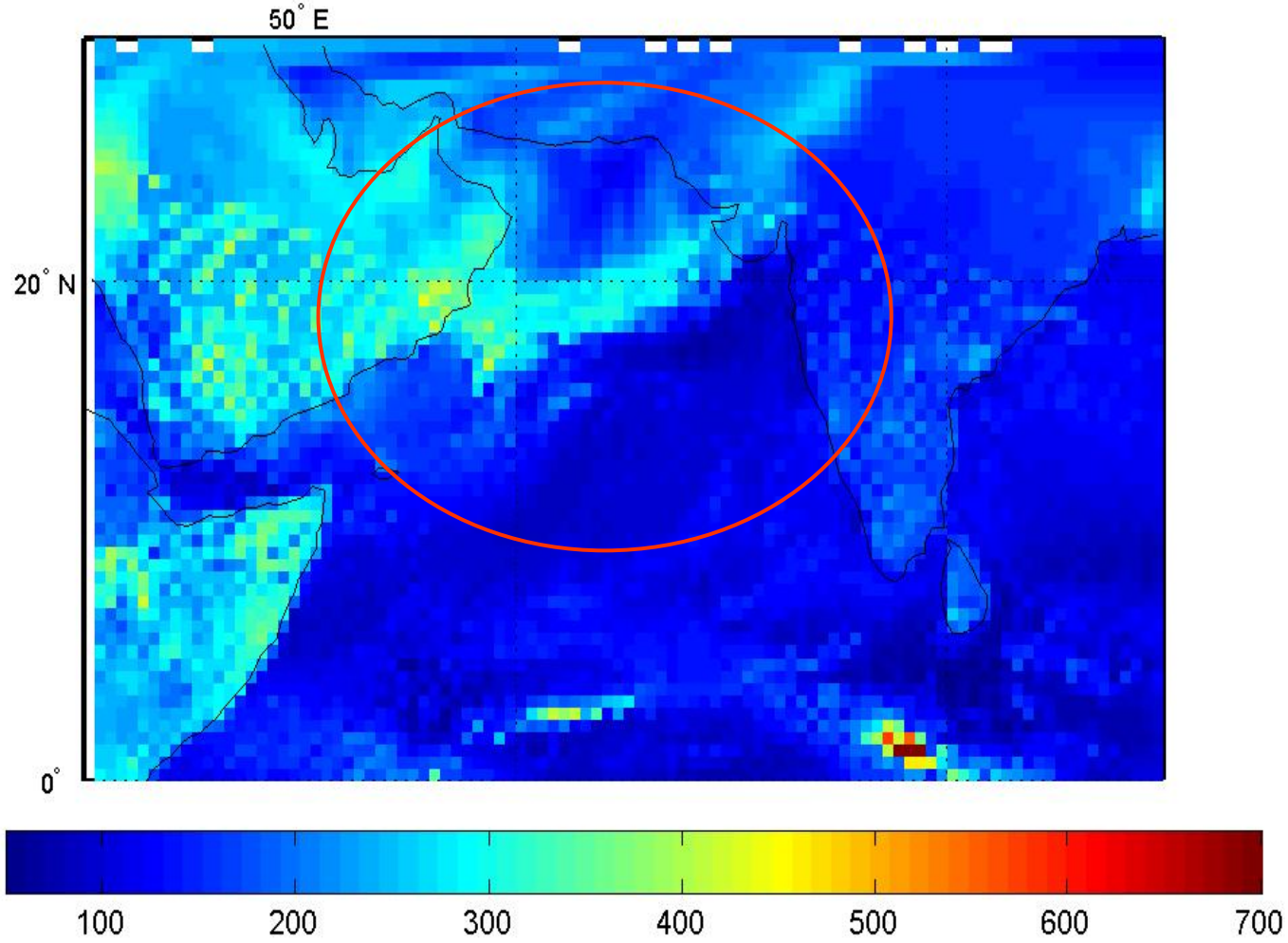
GLOBE_SWIR

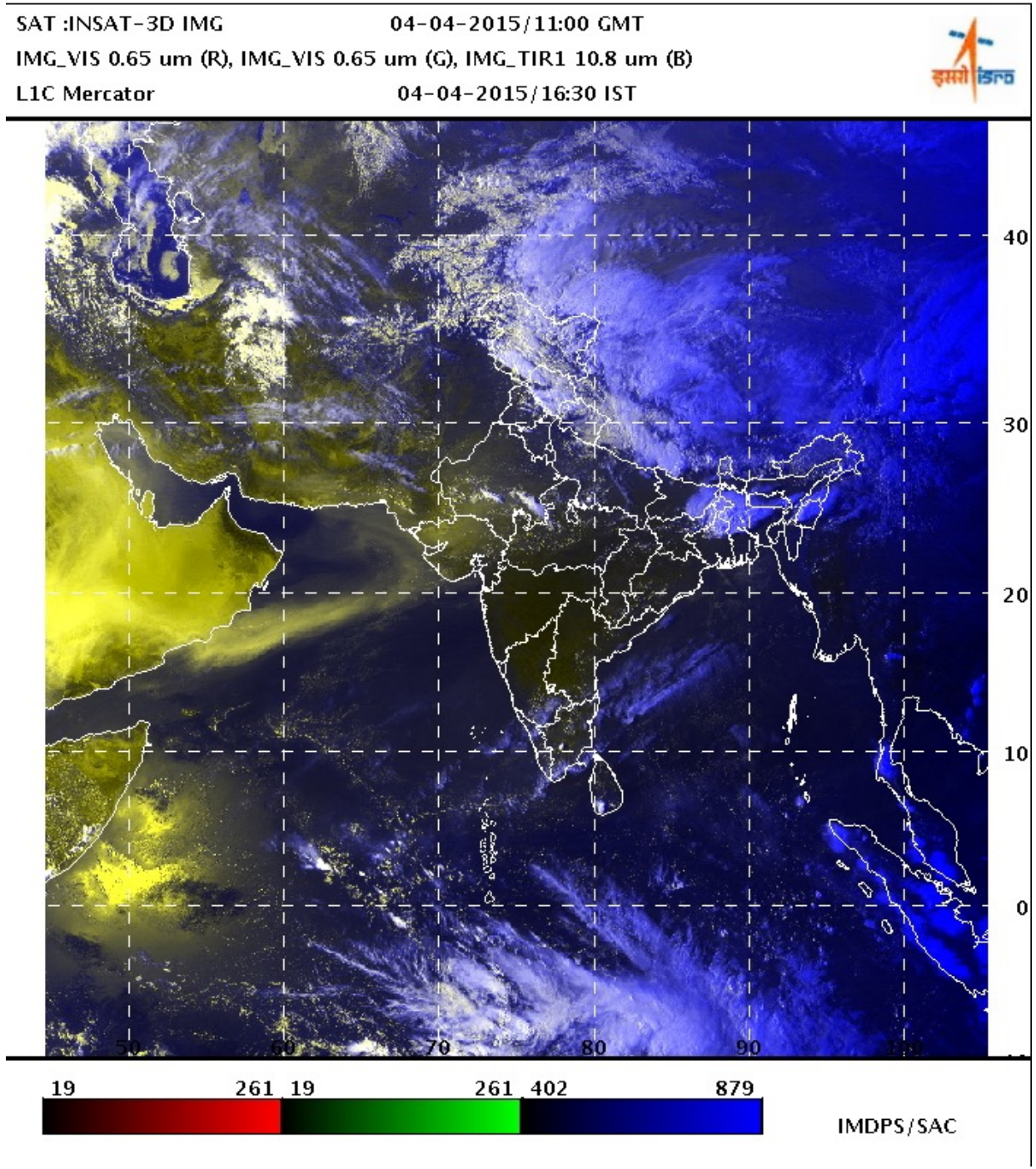
SWIR Linear Stretch 1.0%

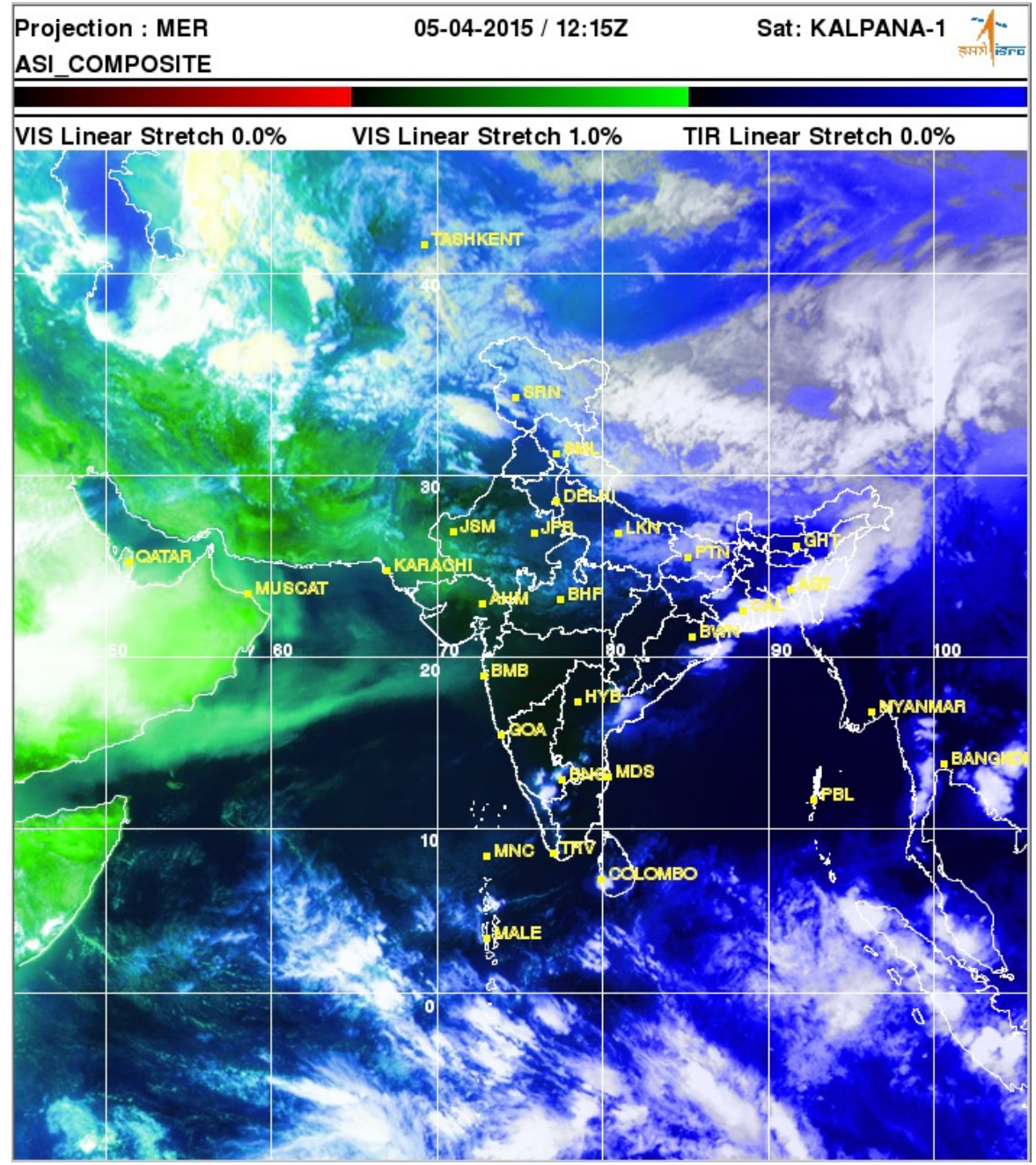


TOA-SW Flux for Dust Plume as seen by MT- ScaRaB

(20 March 2012 Full day Composite)

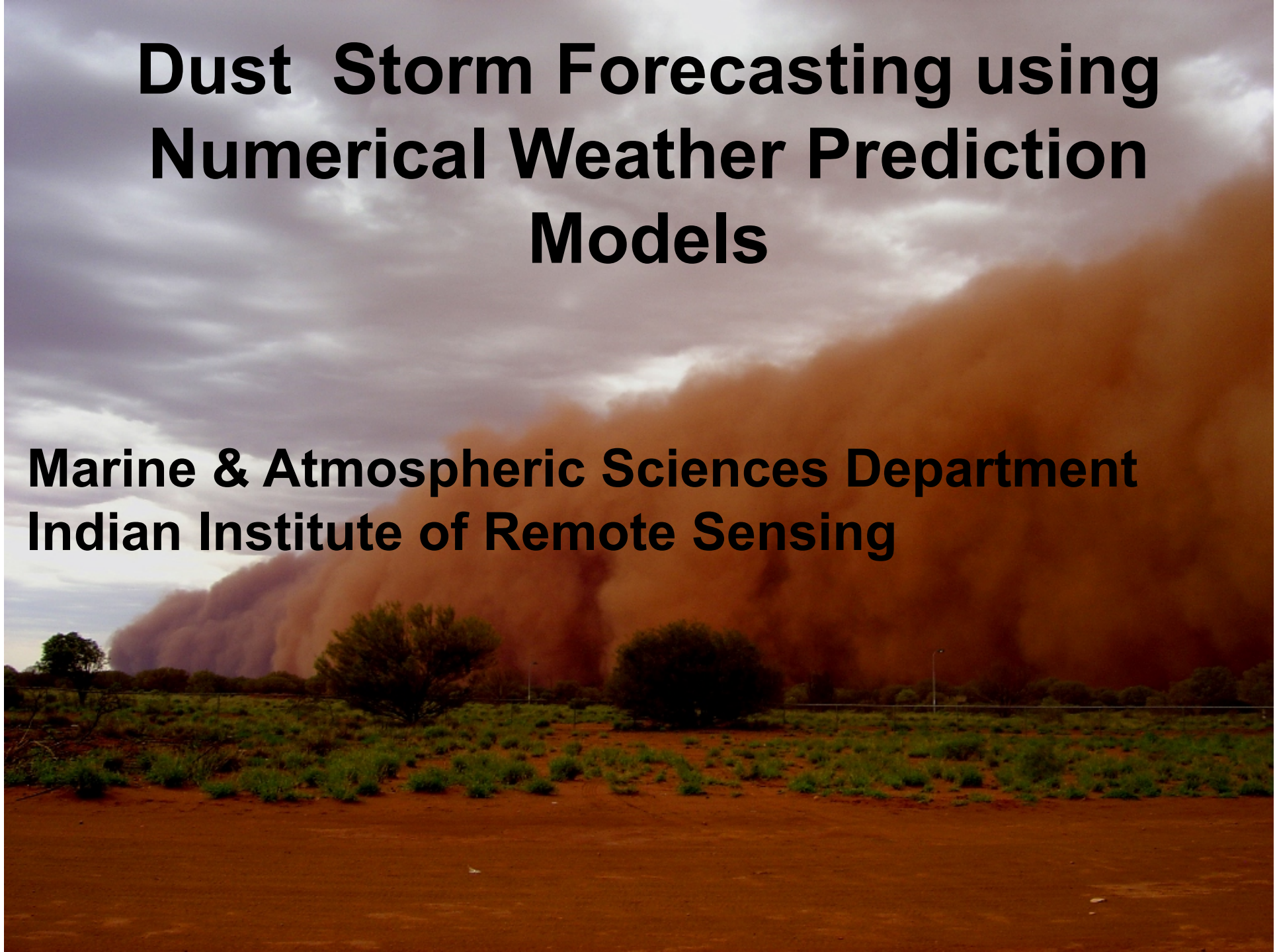



SAT :INSAT-3D IMG 04-04-2015/11:00 GMT
IMG_VIS 0.65 um (R), IMG_VIS 0.65 um (G), IMG_TIR1 10.8 um (B)
L1C Mercator 04-04-2015/16:30 IST
40
30
20
10
0
50
60
70
80
90
19 261 19 261 402 879
IMDPS/SAC


Projection : MER 05-04-2015 / 12:15Z Sat: KALPANA-1
ASI_COMPOSITE
VIS Linear Stretch 0.0% VIS Linear Stretch 1.0% TIR Linear Stretch 0.0%
TASHKENT
SRN
DELHI
JSM
JPR
LKN
PTN
GHT
QATAR
KARACHI
MUSCAT
AHM
BHP
AGT
BMB
HYB
MYANMAR
GOA
MDS
PBL
MNC
TRV
COLOMBO
MALE
40
30
20
10
0
50
60
70
80
90
100

Dust Storm Forecasting using Numerical Weather Prediction Models

Marine & Atmospheric Sciences Department
Indian Institute of Remote Sensing



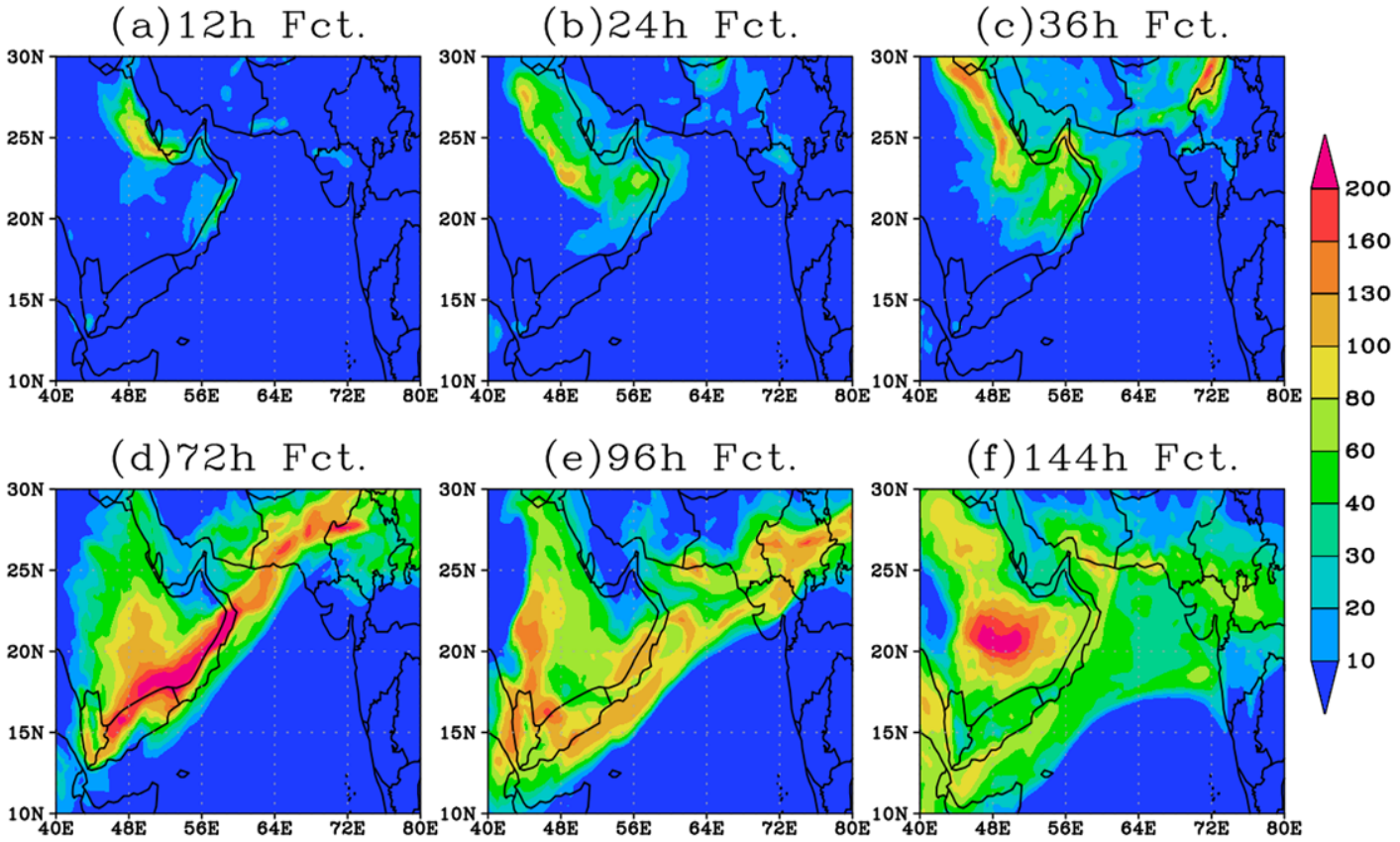
Dust Storm Forecasting

Model Specification

Model:	WRF V3.6
Horizontal Resolution:	25 km
Cumulus Scheme:	Grell-3D
Moisture Scheme :	Lin
Long Wave Radiation Scheme :	RRTM
Short Wave Radiation Scheme:	Goddard
PBL Scheme:	YSU
Dust Model:	GOCART

Initial and boundary conditions: NCEP/GFS
Forecast Length : 144 hours
Starting Date : 31st March 2015

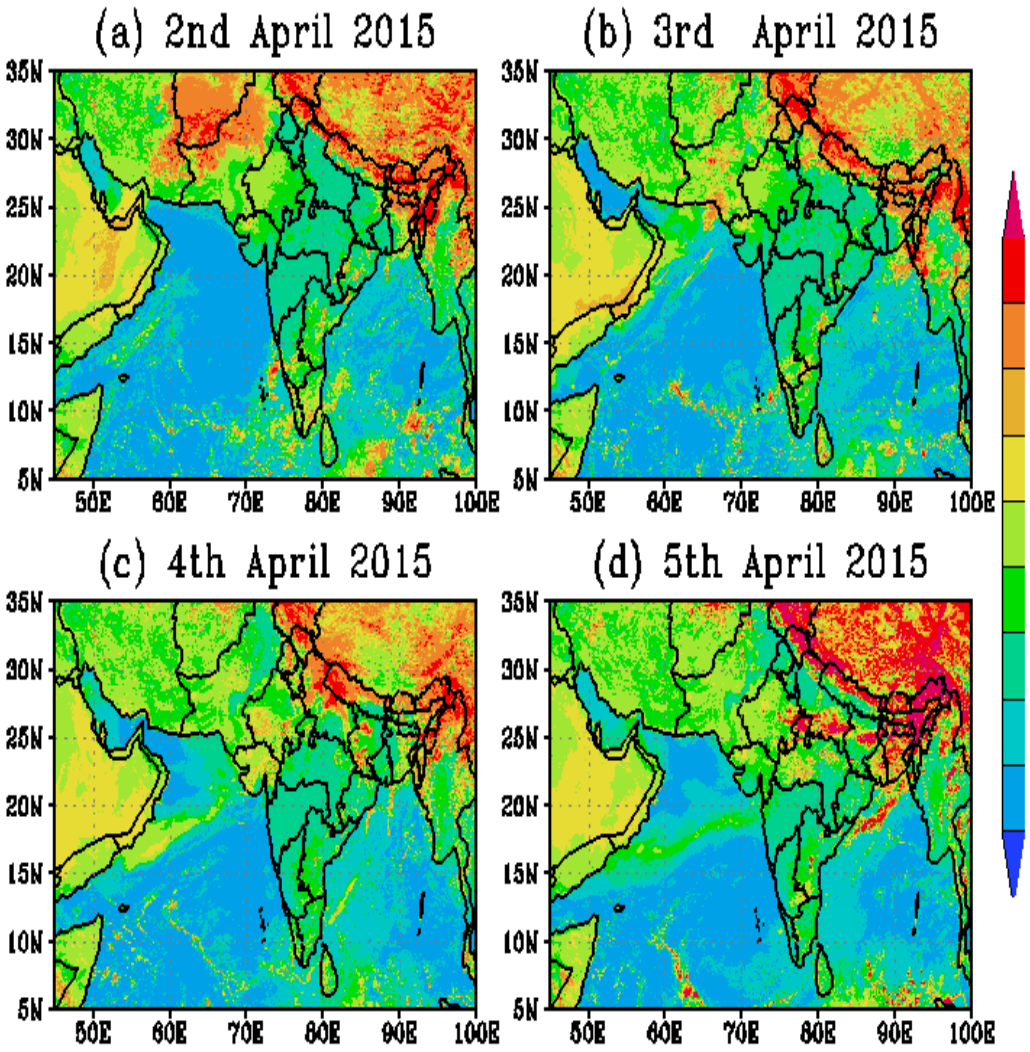
Dust Forecast by WRF model



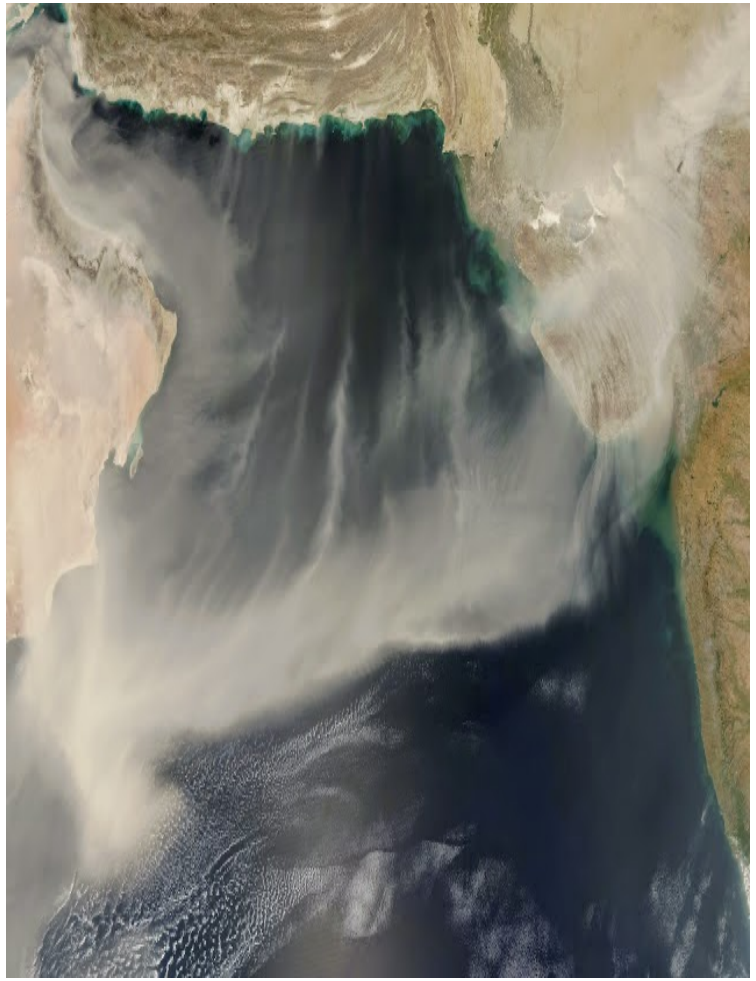
Dust forecast based on WRF-Chem simulations. (a) Spatial pattern of the dust load (mg/m^2) at 12 UTC on March 31, 2015 (b) Same as (a) but for 00 UTC on April 1, 2015. (c) Same as (a) but for 12 UTC on April 1, 2015. (d) Same as (a) but for 00 UTC on April 3, 2015. (e) Same as (a) but for 00 UTC on April 4, 2015. (f) Same as (a) but for 00 UTC on April 6, 2015.

Dust Storm, 2-5th April 2015

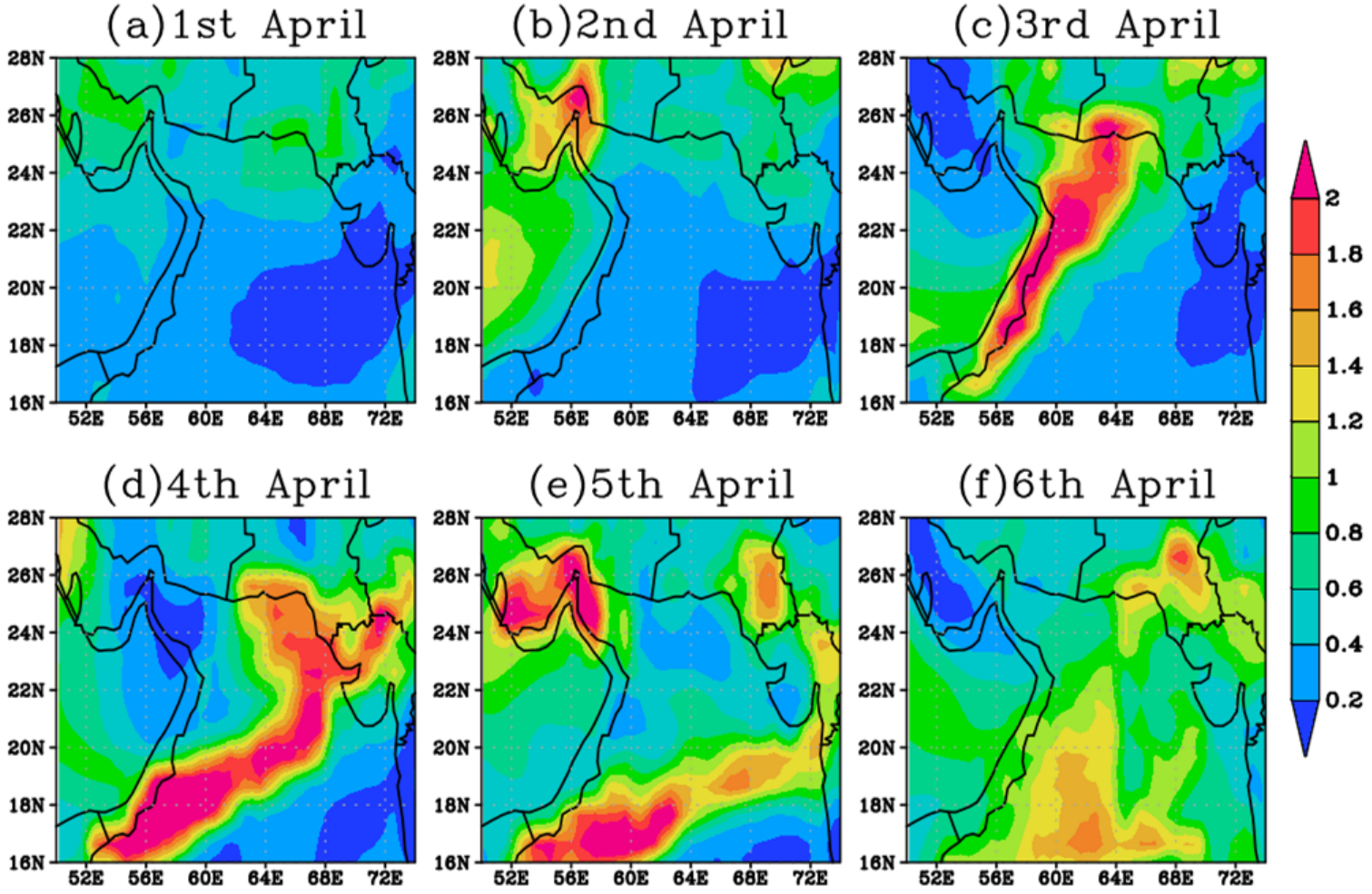
(Dust event captured by INSAT-3D visible channel)



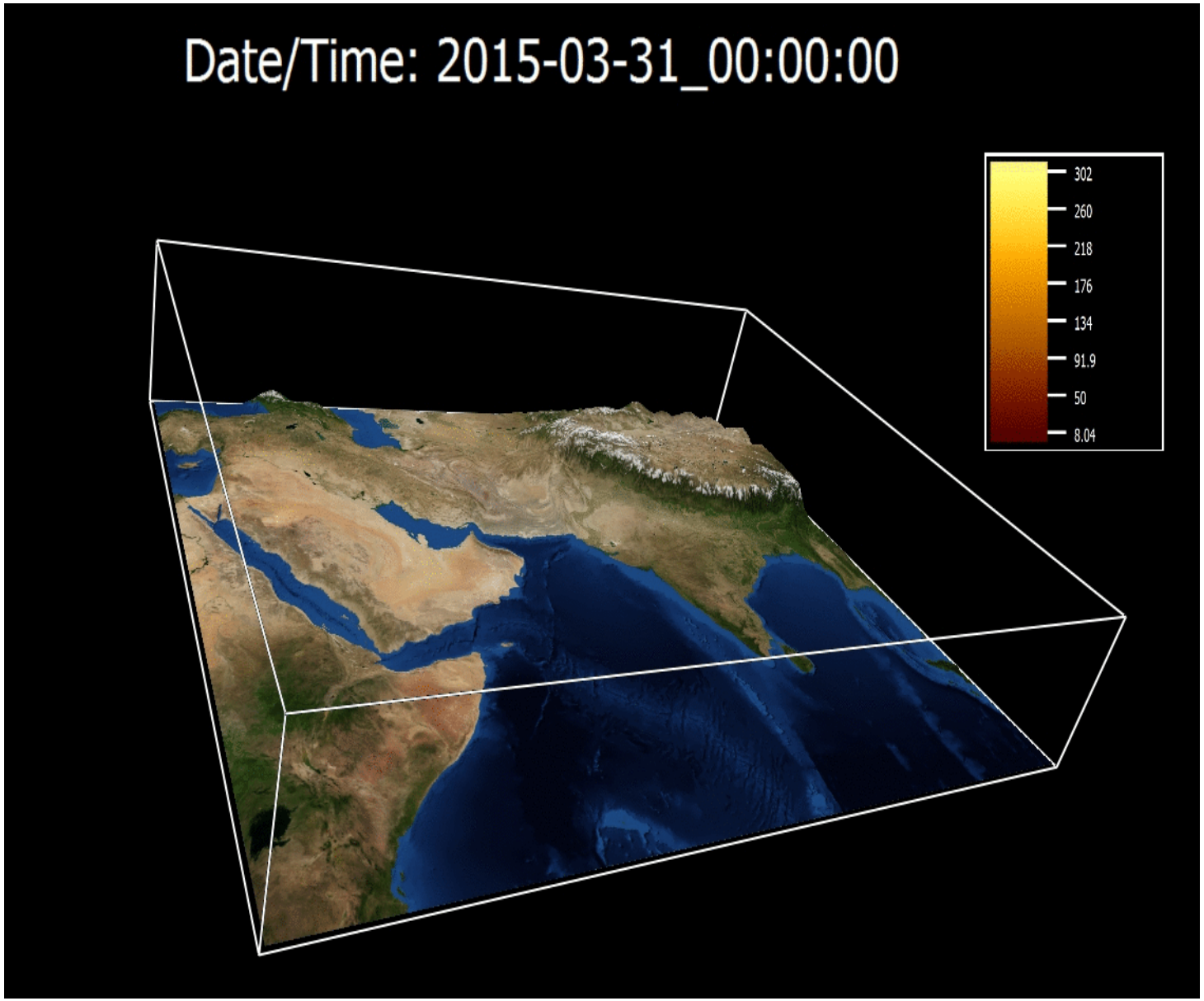
MODIS 4th April 2015



Aerosol Optical Depth



Model Predicted Dust Strom



Future Geostationary Satellites

- GISAT(~2018)
- Visible – 50 m
- 6 Channel IR – 1.5 Km
- Visible and SWIR Hyper-spectral – 500 m
  - ❑ 50 – 60 channels in VIS
  - ❑ 50 – 60 channels in SWIR
- For general remote sensing and can also be used for meteorological purpose

New space based potential instruments from India ..

Upto 5 years

- Microwave sounder(50-60 GHz)
- No of Channels 13
- Temperature profile sounding - Max- 40 Km –Polar orbit

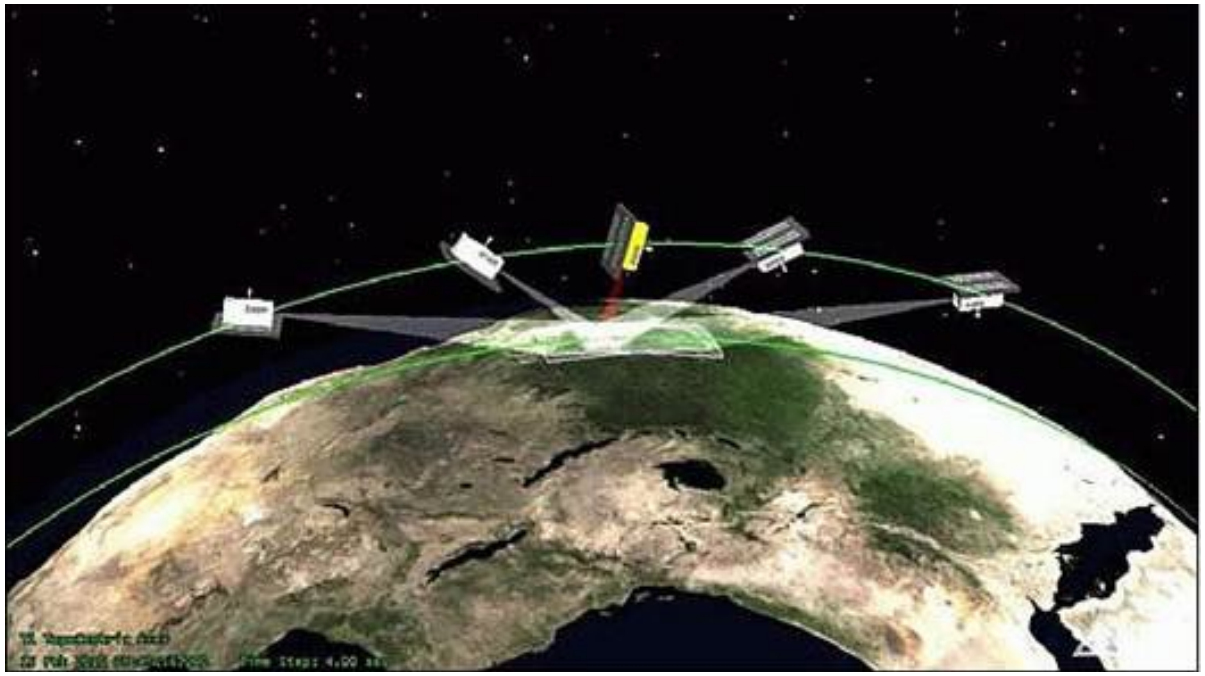
Upto 10 Years

- Microwave sounder (183 GHz)
- No of Channels 6
- Humidity Sounding - 10-12 km - Polar orbit

RESOLUTION - IMPROVEMENT

	Current	Future
Temporal -	Half hour	Few minutes
Spectral -	2 bands to 6-19 channels	>100 channels
Spatial (V) -	2.75 km to 1 km	50 m
(IR) -	11 km to 4 km	1 km

NEMO-AM Mission **Nano satellite for Earth Monitoring and Observation- Aerosol Monitoring**



Multi–Angle Dual Polarisation Imaging Sensor

Parameter	Value
IGFOV	30 m @500 km altitude
FOV	± 4.2deg X ± 1.5deg
Multi–angular view	7 view angles
Quantization	12 bits
Polarised channels	P–S polarised (0–90 deg)
Spectral Bands	480-500 nm, 660-680 nm and 860-880 nm
SNR	@ saturation radiance >90

The unique capability of dual polarisation & multi–angle measurements through MADPI would open new areas of research in the field of aerosol monitoring. This sensor will be launched by Indian satellite (2017-18)

ISRO PLANNING BEYOND 12TH PLAN

NEED TO ADDRESS OBSERVATION REQUIREMENTS

OVERCOMING CLOUD COVER ISSUES

VERTICAL WIND PROFILE

ATMOSPHERIC CHEMISTRY

ECVs

Thanks